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Materials engineering and local mineral resources for development in Cameroon

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Abstract: With latitudinal coordinate of 7.3697° N and longitude coordinate of 12.3547° E, Cameroon is situated above the equator, with an area of 475,440 Square kilometers. Cameroon possesses a huge potential of mineral resources for materials science development. To date, the main minerals mined include iron, rutile, gold, nickel and cobalt, bauxite, diamond, limestone, marble, sand, clay and aggregates. In addition to that, many other mineral resources have been identified. However, these resources are still largely under exploited, with limited industrial activities and less than 1% contribution in the Gross Domestic Product. The main research activities in materials engineering from local mineral resources in Cameroon include their use for building applications, animal husbandry and agricultural application, adsorbents, purification materials and materials for electrochemistry application. This paper reviews the Cameroon's mineral resources as well as some research and industrial activities in materials engineering, in order to better highlight the country's potential and actions to be taken for a better contribution of local minerals in the country socioeconomic development.

I. Introduction

A Mineral Resource could be defined as a concentration or occurrence of solid material of economic interest in or on the earth's crust in such form, grade or quality and quantity that there are reasonable prospects for eventual economic extraction (Ibarra-Gutiérrez *et al.,* 2021).

Mineral resources can find application in a wide range of engineering fields, with potential to play a significant role in the country's socio economic development of any nation (Biney *et al.,* 2022). The presence of high mineral potential in countries like Cameroon is an additional advantage for materials engineering development. Cameroon is situated above the equator, with an area of 475,440 Square kilometers, latitudinal coordinate of 7.3697° N and longitude coordinate of 12.3547° E. The country possesses a huge potential of mineral resources including iron, rutile, nickel and cobalt, bauxite, diamond, gold, uranium, limestone, marble, sand, clay and aggregates (Kamga *et al.*, 2018; Weng and

Margules, 2022). However, these natural resources remain largely unexploited. Only a few companies and economic activities are ongoing on their valorization, with a contribution to the Gross Domestic Product being less than 1%. Besides, the main research activities in materials engineering from local mineral resources in Cameroon include their use for building applications, animal husbandry and agricultural application, adsorbents, purification materials and materials for electrochemistry. These research activities are mainly conducted by the state universities and research institutions under the Cameroon Ministry of Higher Education and the Ministry of Scientific Research and Innovation, in collaboration with local and external partners. This paper reviews Cameroon's mineral resources as well as some research and industrial activities in materials engineering, in order to better highlight the country's potential and actions to be taken for a better contribution of local minerals in the country socioeconomic development. The methodology used to collect information included searching on websites of institution involved in materials engineering of state Universities, research institutions under the Cameroon Ministry of scientific research and innovation and the Ministry of Mines and Technological Development. The word "Cameroon" was also used as key word for collecting online information in scientific data bases that included Science Direct and google scholar.

II. Potential of mineral resources for development in Cameroon

Literature identifies different types of mineral resources like energy, ore, industrials minerals and building materials (Kamga *et al.,* 2018; Philémon *et al.,* 2016b; Yamb *et al.,* 2016). Some industrials minerals and building materials constitute what is often called "development minerals" which are highly neglected in ACP countries[1]. From toothpaste to paints, and buildings to plates, the mining of development minerals are intrinsic to everyday life. Cameroon's potential in these mineral resources no longer needs to be demonstrated. However, geological mapping and overall knowledge of the country's mining potential remain very limited and more than 50% of the territory remains unknown (Kamga et al., 2018). These geological resources constitute basic raw materials in the development of materials engineering, with the finality of setting up goods and services.

a) Geology of Cameroon and related mineral potential

Cameroon's geological history starts with the Archaean era between 3.5 and 2.5 billion years (Ga) ago; Its different phases of development are illustrated by geological masses formed during successive orogenic cycles characterized by the formation of mountain ranges, and subsequent extension phases by the splitting of the continental crust (Fuh, 2013; Noel *et al*., 2014). Three orogenic cycles are defined:

- The Liberian cycle, illustrated by the Ntem complex, which dates from the Archaean era, and is about 2.5 billion years old.
- The Eburnean or Trans amazonian cycle, with the Nyong and Ayna formations, which date from the Palaeoproterozoic period (2.5-1.8 billion years ago);
- The Pan-African cycle, which comprises formations from the Neoproterozoic era 1,000-600 million years (Ma) ago.

This geology is favourable to the mineralization of substances as precious metals, base metal, rare metals, and hydrocarbons. Example are:

http://developmentminerals.org/index.php/fr/pays/cameroun , consulted on 30 August 2022[1]

- Congo Craton with Archaean Greenstone belts at the southern part of the country, the Dja series. Identified minerals are: iron ore at Mbalam and Kribi, uranium at Lolodorf, Diamond at Mobilong, etc.
- Central Cameroon shear with Poli series in the Northern part where we had minerals like uranium, sapphire and gold.
- Sanaga shear zone with Lom series (East) for gold;
- Pan African Mobile Belt for placer gold;
- Sedimentary basins for oil & gaz (Douala, Campo, Kribi), salt and sapphire (Mamfe).

Mineral resources of Cameroon can be grouped as: i) precious metals and precious stones (diamond, gold, sapphire, kyanite), ii) construction materials (clay, quartzite, sand, gravel stone like marble and granite), iii) ores (iron, alumina, nickel and cobalt), and iv) energy minerals (uranium). Figure 1 summarises the potential of mineral resources in Cameroon.

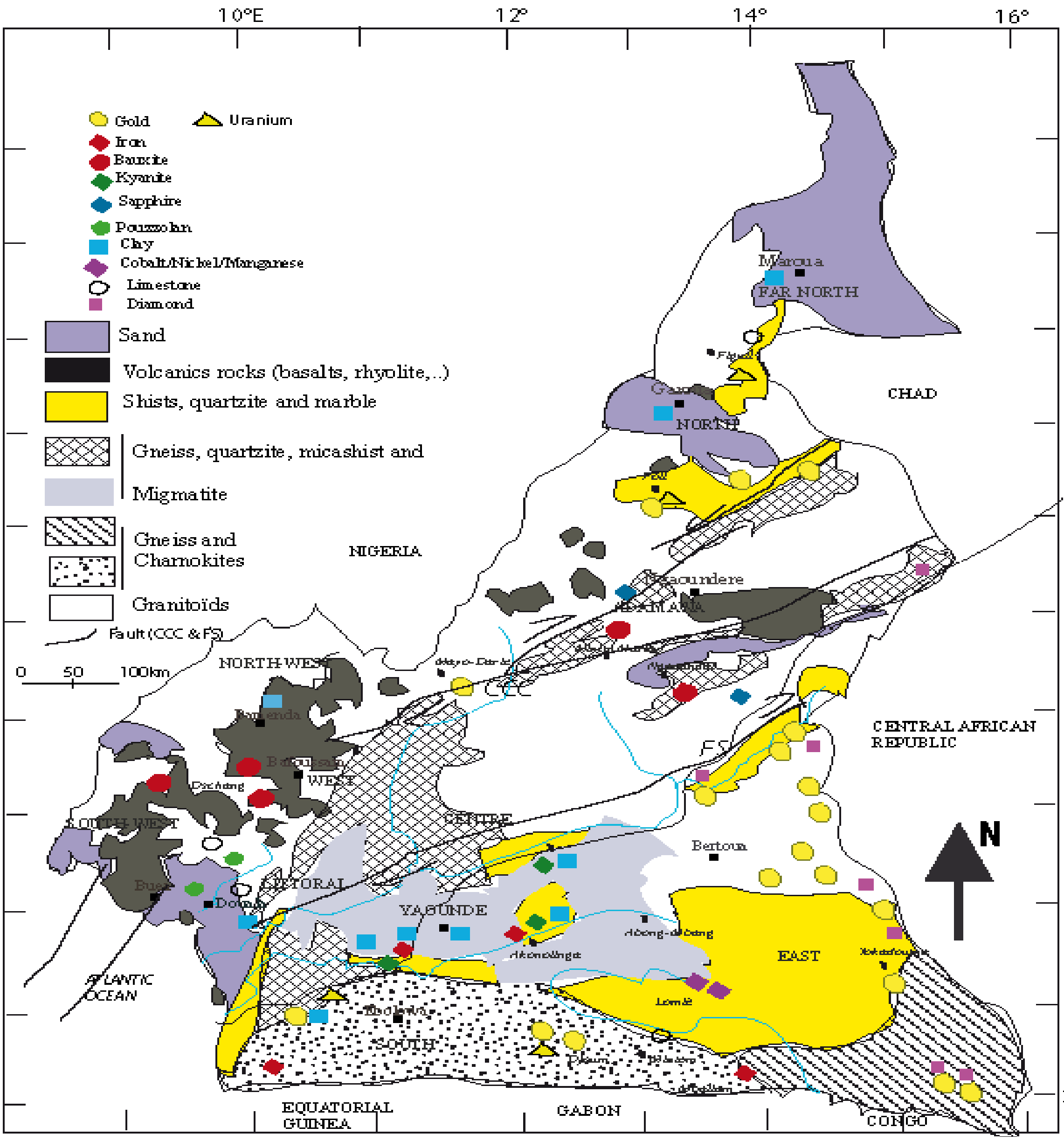

Figure 1: Potential of mineral resources in Cameroon (IRGM, EITI & PWYP, modified)

b) Development minerals

Development minerals include industrial minerals and building materials. The application sector of industrial minerals is very wide (metallurgy, chemicals, glassware, ceramics, cosmetics, housing, automotive, stationery, etc.).

- ✓ **Industrial minerals**

Diamond

The known diamond deposit in Cameroon is that of the Dja series, locality of Mobilong located in the municipality of Yokadouma, in eastern Cameroon and not far from the border with the Central African Republic. This deposit is the mining property developed by the Cameroon & Korean Mining (C&K Mining) company. Its valuation is estimated at 420 million carats, which would make it one of the largest diamond deposits in the world. Seventeen (17) targets documented out of which nine (9) are presently exploited by artisanal industry. About twenty-six (26) small-scale mining sites exist. Significant diamond occurrences discovered along 700 km border with Central African Republic. Other diamond rich areas in the Est region are Ketté, Boubara, Lom, Boumbe-2, Betaré-Oya, Yokadouma and Gari-Gombo (Fig. 1). Also, little traces are found in Poli (North) and Mamfe (South-West) (CAPAM)[2].

Sapphire / Corundum

Corundum occurrences were discovered in Cameroon since 1966, in secondary deposits, within clastic sediments overlying assumed Cretaceous ages sedimentary rocks in the Mamfe Basin, Southwest Region of Cameroon (Paul Mbih *et al.*, 2016). They have been mined in alluvium, colluvium and eluvium in other parts of the country. The most productive deposits are found in Mayo Kewol, Paro Lawel, Mayo Dankali, Marma, Karange, Tignere and Tibati in the Adamawa region of Cameroon (Boaka à Koul *et al.*, 2010; Kanouo *et al.*, 2012; Paul Mbih *et al.*, 2016).

Rutile / Kyanite

More than sixty-five (65) targets have been identified and are often associated with kyanite and garnet. Total production was 16,500 tons and during the 2nd World War the contribution of mining activity to the economy had reached 20%. Studies of the rutiliferous potential in the Akonolinga, Nanga-Eboko and Otélé zones gave a partial evaluation of more than 300 million tonnes (in the tributaries of the major collectors and reservoirs, the Sanaga and the Nyong). Official data estimate nearly 3 million tons of rutile, including 500,000 tons located in Akonolinga, the world's second largest reserve behind Sierra Leone. Geochemical analysis by XRF technique revealed that the rutile in the area is of high quality, with a TiO_2 content > 96 wt%, and subordinate Fe_2O (2.2-3.1 wt%), and minor amounts of Al_2O_3, SO_3, K_2O P_2O_5 and Mn_2O_3 (Agyingi *et al.*, 2009). Currently, this substance is being explored by the French company Eramet. Other localities where rutile have mostly concentrated are Nkol-Afamba, Sack-Bayeme and Fifinda (Betsi et al., 2020; Ngo Bidjeck Bondje et al., 2020), Lobo (Nyobe *et al.*, 2018), Matomb (Tonje et *al.*, 2014), and Dibang, Abong Mbang and Akonolinga (Stendal *et al.*, 2006), and Nkolembonda in the southwestern Cameroon (Cédric *et al.*, 2022).

[2] https://www.minmidt.cm/capam-2/, consulted on 18 September 2022

Kyanite, around 200 000 tons was discovered in the localities of Otite and Nanga-Eboko in the Centre region (INS, 2022).

Tin

Seventeen (17) tin targets, expressed as cassiterite (tin oxide), have been identified in Cameroon. We can cite the Mayo-Darlé deposit, the alluvium and eluvium of which were the subject of ancient artisanal mining with 6,500 tons of cassiterite extracted from 1933 to 1968. The mining engineers and geologists of the time (1940s and 50) described this deposit as very rich and its primary potential remains to be defined.

Kaolin

Some Cameroonian localities exhibit kaolin clues such are Mayoum in the West region *(Njoya et al.,* 2006; Nkoumbou *et al.,* 2009) and Mankon in the North-West region (Nzeukou Nzeugang *et al.,* 2018). The Mayouom Kaolin deposit is located in the West Region – Cameroon, about 30km from Foumban (Fig. 1). The locality belongs to the Foumban Shear Zone where a Neoprotezoic mylonitic band (500 – 600 Ma) appears in an intrusive magma (< 40 Ma). The basement consists of granite and orthogneiss with similar mineralogical compositions. Mylonite is a band 4 to 6 km thick oriented SW-NW and crossed in places by quartz veins. The cubage is not yet available. However, many wells and hand auger surveys have been carried out in the various hills. The waste rock shows a thickness of less than 1 m, and these wells have not reached the basement because of the frequent emanation of an unknown gas below 6 m. The mylonitic band extends SW-NE over 2 km x 0.5 km. Due to its high kaolinite content (up to 85%) and the low iron mineral content (<1.5%), Mayouom kaolin is a suitable raw material for white burning industrial clays.

Talc

A talc deposit from Lamal Pougue in the Boumyébèl area at about 93 km from Yaoundé (Centre region, Cameroon) (Nkoumbou *et al.,* 2009; Woguia *et al.,* 2021).

Quartz

The quartzites are located in the localities of Pouma, Sa'a, Mbalmayo. The fresh quartzite formation in the Pouma locality stretches along the Douala-Yaoundé axis over 1871.4 m and 1991 m for the slightly altered formation (Jude *et al.,* 2021) .

Feldspar

The located deposits area in Cameroon are Eboundja, South region (Emmanuel *et al.,* 2013), Boboyo, Far-North region (Kanouo *et al.,* 2019), Bagangté, West Cameroon (Tchouankoué, 1992), Monguélé, south east Cameroon (Vicat and Kenguemba, 1999) and Linté, Centre region (Mouliom *et al.,* 2022). The Eboundja deposit is a nepheline syenite made up of an elongated massif 8 km long by 1 km wide, with a SW – NE axis, dominating the coastal plain by about 80 m. The average contents of the major elements before treatment are as follows: SiO_2 = 55.19%; Al_2O_3 = 21.96%; Fe_2O_3 (total) = 3.77%; Na_2O + Ka_2O = 14.97%. The dimensions of the syenite deposit give an idea of the overall volume in which the exploitable mass is included: length 8,000 m; width 1000m; thickness 40m; (8,000 * 1,000 * 40), i.e., 320 million m^3.

✓ Building mineral

Building minerals are generally used for the construction of building, roads and railways. They include clay, pozzolana, limestone, marble, gravel, sand, and dimensioned stones.

Clay

Clay deposits were localized in majors part of the country. Estimated tonnages include (30-70) x104 m^3 observed at Nanga-Eboko and 220 000 m3 at Ebebda in the Centre region (Nzeugang Nzeukou *et al.,* 2013; Nzeukou *et al.,* 2013), 2 550 000 tons in the Bomkoul area (Mipromalo), Douala, littoral region, 875 x 106 tons in the Monoum plain (11372 ha), west region (Bomeni *et al.,* 2022).

Pozzolana

A pozzolana deposit is in operation at Djoungo between Douala and Nkongsamba, but the evaluation work can highlight large deposits of volcanic ash with a pozzolanic effect (Tchamdjou *et al.,* 2015) particularly in the volcanic zones of the South-West, West and North-west where Strombolian activity has been frequent.

Limestone

Six (6) limestone targets and deposits have been identified, including the Figuil deposit (600,000t of reserves) which is exploited for cement works (Yamb *et al.,* 2016); the Moungo, Bogongo, Logbadjeck and Kompina deposits, in the sedimentary basin of Douala (Billong *et al.,* 2020), then the Ngol Veneer Travertines, and the Mintom deposit, in the upper Dja series (Bisse *et al.,* 2018; Philémon *et al.,* 2016b). An exploration permit is held by CAGEME Sarl on the Mintom deposit.

Marble

A marble deposit is known in Bidzar, one of the fields with reserves of 2.5 million tons. This deposit has continuity in the Biou zone (Lyonga *et al.,* 2022; Wouatong *et al.,* 2017). It has been operated for more than forty years by the company ROCAGLIA, which produces an average of 5000 tons of marble per year. CIMENCAM has just obtained the exploration permit there for the needs of the local cement plant.

Sand

There are industrial quantities of sand as a construction and servicing materials, but there is also pure sand for glassmaking, like the Manoka deposit (sea coast) operated by SOCAVER for the production of bottles used in particular for the breweries.

Gravel

The geology of Cameroon shows that more than 80% of the territory rests on the crystalline base (**Fig. 1**), like hard rock or stone. Those rocks are transformed by suppliers to produce gravel and dimensioned stones.

c) Other minerals

Iron ore

Cameroon's potential in ferrous resources covers several localities and according to KPMG (KPMG, 2014), about twenty-five (25) targets occurrences have been discovered including Mbalam (in the east), Nkout, and Lobé (in the south). The geological context of those formations is constituted by an Archean to Proterozoic cratonic basement (2500 to 600 Ma) and comprises the Ntem Formation (Ntem Complex, Dja Series and the Nyong series) (Anderson *et al.,* 2014; Sylvestre *et al.,* 2017) (Fig. 1). These rocks have been metamorphosed and include quartzites, schists, amphibolites, charnockites, greenstones, granulites and gneiss. The bounded iron formation (BIFs) in the region is Archean in age, hosted by greenstones (Moudioh *et al.,* 2020). Some exploration industry key facts are the Mbalam, Kribi, Nkout and Bikoula projects.

The Mbalam ore deposits, rich in hematite represent 775.4 million tonnes with 57.2% iron and 95% of this deposit is classified as "indicated" in accordance with the JORC code (Joint Ore Reserves Committee), which is part of the international standards for the most accurate estimation and targeting of a deposit[3]. Cam Iron S.A (90% Sundance Resource) owns the permit in this area, and would probably have the capacity to mine 40 million tons of iron ore annually over 12 years, in its first phase of development. Fe concentration increases from average of 46.18 wt% to 79.08 wt% (Nforba *et al.,* 2011). The Nkout ore deposit, a locality located about twenty kilometers from Djoum, in the South region of Cameroon, has the same geological environment (Congo craton) as the iron deposit of Mbalam and the belt of iron formations extend up to in Gabon and Congo (Anderson *et al.,* 2014; Ndime *et al.,* 2019) . It is the mining property of the Affero mining company (Caminex S.A), and is considered the largest deposit and hosts according to current estimates of resource of 2 billion tons, expandable to 4 billion tons. Current mineral resource stands at 1.2 Bt grading 32.9% Fe, and covers approximately 8.9 km of the total 20 km strike length.

The Lobe (or Mamelles) ore deposit in Kribi is a small deposit compared to the others. Major oxides are Fe_2O_3 (72–76.40 wt%), Al_2O_3 (2.80–5.43 wt%), and SiO_2 (16.70–18.35 wt%) (Soh Tamehe *et al.,* 2020; Teutsong *et al.,* 2021). It covers an area of 978.3 km^2. The overall reserve highlighted is 632 million tonnes at a content of 33%, therefore requiring to be enriched to at least 60%. It is the property of SINOSTEEL CAM S.A. The Bikoula ore deposit, is nearby Nkout-Akon-Djoum (Teutsong *et al.,* 2021). The preliminary analysis from core samples collected from drilling under completion reveals 55.5 to 57.3% Fe. It is explored by Aucam & Aluvance Mining company. Other localities with iron potential are Kouambo and Bipindi (GeoCam Mining), also located in the Southern part of the country (Moudioh *et al.,* 2020; Sylvestre *et al.,* 2017).

Nickel-cobalt-manganese

These three ores were discovered in the Nkamoua area near Lomié in the eastern part of the country (Yongue-Fouateu *et al.,* 2006) (Fig. 1). The deposit is the property of Geovic Mining Corp. The data show that the potential of the deposit is 121 million tons of mineral resources, with average grades of 0.23% for cobalt, 0.65% for nickel and 1.35% for manganese (KPMG, 2014). It is developed on serpentinized peridotite. As mineralogy and geochemical composition are the key factors in the economics and processing of laterite deposits (Gleeson *et al.,* 2003), the Nkamouna deposit is enriched in Co and Mn, with sub-economic Ni grades and will be mined primarily for Co. Lithiophorite is the

[3] https://www.sundanceresources.com.au/irm/content/annual-reports.aspx?RID=233, consulted 30 August 2022

most common Mn mineral and is the main host of Co, Mn and a significant proportion of Ni. It occurs as coatings in pores and on other mineral grains and as concretions and impregnations in the matrix. The structure and mode of occurrence of the lithiophorite makes Nkamouna ore amenable to physical beneficiation, producing a concentrate with Co grades 2.3-4.5 times higher than the run-of-mine ore (Lambiv Dzemua *et al.,* 2013). Nickel: 27 clues detected in Masséa, Yokadouma, Mintam, Rainy. Cobalt: 06 indices and deposits counted in Lomié (Kongo, Mang, Masséa, Kondong) over 240 km2. 02 other clues noted in Ngoïla and Mbalam. Manganese: 12 known showings related to serpentinites, conglomeratic sandstone, laterite, paragneisses, basalts (MINIMIDT)[4].

Alumina

The alumina deposit in Cameroon consists of the bauxite formations of Mimi-Martap and Ngaoundal (in Adamawa region), and Fongo-tongo (in West region) (Fig. 1).

The Adamawa bauxite deposit is operated by Cameroon Alumina Limited (CAL) – a joint venture between Hydromine, Dubai Aluminum Company and Hindalco Industries. The Australian mining junior Canyon Resources has published the results of the last research phase of its project on this deposit, which has enabled it to identify 65 additional bauxite plateaus (bringing the total to 79). By analysing only 16 of the 79 targets, the project's potential is estimated at 892 million tonnes, including 250 million at " very high grade ", ideal for aluminium production. The resources are estimated at over one billion tonnes at an average grade of 41.3% alumina in Minim-Martap. For Ngaoundal, the bauxite resources are estimated at 120 million tonnes with 41-43% alumina.

The Fongo-Tongo deposit is estimated at 46 million with an average grade of 47% alumina. Overall, the geochemical data prove to reveal the persistence of high alumina (Al_2O_3) content, ranging from 37.4 to 57.5 wt%, with relatively low Fe_2O_3 (<29.5 wt%), TiO_2 (<7.5 wt%) and SiO_2 (0.48-3.21 wt%) (Dongmo et al., 2019). In Bangem, in the South-West Region, there is an estimated 19 million tons reserve deposits, expandable by 30 million tons. CAPAM, Cameroon's mining arm, also reports 4 million tons in Foumban, in the Western Region.

Gold

The eastern part of Cameroon is the most prospective area for gold resources (Fig. 1). About one hundred and forty (140) targets discovered essentially at Yokadouma, Lom, Mbéré and Mayo-Rey range (Djibril *et al.,* 2017; KPMG, 2014), and Colomine (Gentry *et al.,* 2021) . The sector is still strongly dominated by small miners and the latter still escape all control despite the government's efforts to control production, but especially marketing.

In addition to Codias SA, which is to develop the small Colomine gold mine in the east of the country, the mining company Oriole Resources is active on the Bibemi and Wapouzé gold projects. African Aura Resources-Aureus (UK) is in the exploration phase and prospection permits in several regions like Batouri, Tchollíré, Akonolinga or Rey-Bouba. Fametal Mining Resources Cameroon (FMRC) is in the exploration phase at Mang, Boulou, Mompwe (East). The South Africa company (Caminco) has gold exploration permits in the North. The Cameroonian company (Bocom) also have a research permit in the northern part (Vaîmba area) of the country (Penaye, 2013). The new gold deposits include Misaje, Bipindi-Lolodorf, Batouri, Sangmelima, Mamfe, Ebolowa, and Okola.

[4] https://min-midt-gov.com/, consulted September 17th 2022

Copper

About fifty (50) targets have been highlighted in relation to the Bas-Nyong unit of the Ntem group in the south, the lower Dja series in the extreme south-east of the country, the basement-Dja series contact in the south of the district of Yokadouma, the group of Yaoundé, the ferriferous furrows and the unit of Ntem in the South, the microclinized and granitized bedrock of Adamawa, the major Foumban-Ngaoundéré accident, the series of Poli in the North, the ditch of the Mbéré, the series of Yokadouma (KPMG, 2014). The largest number of clues is found in the detailed inventory zone south of the 4th parallel. A research permit has been granted to the South African company CAMCOM Sarl on the Ngoila copper deposit (East Yokadouma).

Energy minerals (Uranium)

About fifty uranium targets were highlighted, most of which, in the form of geochemical anomalies, were detected by the systematic mining inventory work carried out from 1978 to 1987 by the South-East mining projects (United Nations) and South-West (collaboration with the French Bureau of Geological and Mining Research). The Mega Uranium company, holder of the research permits, is carrying out advanced research work in Poli and Teubang in the North, in Lolodorf in the South, in Ngombas in the Center. According to Ministry of the Economy, Planning and Regional Development, a uranium deposit of more than 1300 tons was discovered in Poli. But, the real potential of Cameroon remains to be defined[5].

d) New potentials clues

Thanks to World Bank support for the Mining Sector Capacity Building Project (Precasem), an airborne geophysical survey campaign, carried out between 2014 and 2019, has identified up to 500 new virgin sites. These mining sites cover a total area of 160,000 km² and are concentrated in five regions of the country, namely: East, West, Adamawa, North and Center. Minerals vary from gold to rare earths elements, base metals and uranium. Niobium–tantalum oxide minerals have also revealed in alluvial deposits from the Ngoura area, East-Cameroon (Bidzang *et al.,* 2020). “After five years of studies, with the support of the World Bank, more than 300 new deposits have been identified in five (05) regions: Copper, gold outside the Eastern region, uranium, lead, zinc, especially the rare earths elements. **Table 1** shows distribution, by region of "proven" and “undeveloped" deposits of raw materials in Cameroon (Tita, 2020).

To better valorise mining activities, the “Support for the Development of Mining Activities” (CAPAM) was created in 2003 by the Prime Minister Head of Government, then, the national mining corporation “(SONAMINES)”, was created in 2020 by the President of the Republic of Cameroon decree n°2020/749, with main mission to develop and promote the mining sector in Cameroon, with the exception of hydrocarbons and quarry materials, and manage the interests of the State in the domain[6].

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https://fortuneofafrica.com/cameroon/2014/01/31/proven-oil-and-gas-reserves-in-cameroon/, [5] consulted on 30 August 2022

[6] Decree N°2020/749 of 14 Dec 2020 to set up the National Mining Corporation

Table 1: Distribution, by region of "proven" and "undeveloped" deposits of raw materials in Cameroon (Tita, 2020).

Interpretation of satellite photos of 35 mining zones where there are proven undeveloped deposits	List of products	Estimate (tons) of proven undeveloped reserves
Akonolinga	Titanium, rutile, garnet, ilmenite Wolframite, pechblende, chromite, pyrochlore	3 000 000 tons
Menoua	Aluminum, bauxite	5 000 000 tons
Kadeï basin	Gold	5 tons
Batouri	Gold	5 tons
Bétaré Oya	Gold, bismuth, molybdenum lead, wolfram, diamond	20 tons
Bouendjo, Edéa Eboundja, Kribi	Wolframite, pechblende, chromite, pyrochlore	400 000 tons
Paro Lawel	Sapphire	10 tons
Center – West	Bauxite, alcretes	500 000 tons
Colomines	Gold, diamond, gemstones	20 tons of gold
Dubreuil	Titanium, ilmenite, wolframite, pechblende, chromite, pyrochlore	400 000 tons
Eboundja	Syenite, nepheline, feldspar	20 tons
Fokoué Fokamezoun	Bauxite, alcretes	1 000 000 of tons
Garga-Sarali	Ilmenite, wolframite, pechblende, chromite, pyrochlore, niobium – columbium tantalum (Ta_2O_5), tin, gold	1 000 000 of tons
Tamonéguézé Ketté Irderé	Industrial diamonds and gem diamonds	10 000 carats
Kambélé	Gold, diamond, and other gemstones	100 tons
Kongo Nkamouna Lomié Mang Messea	Cobalt, nickel, manganese	55, 61 and 17 million tons respectively
Kribi, Les Mamelles	Iron	10 million tons
Mboutoundou	Gold	2 tons
Mewongo	Iron, manganese	100 000 tons
Nanga Eboko	Ilmenite, wolframite, pechblende, chromite, pyrochlore, titanium	1 000 000 tons

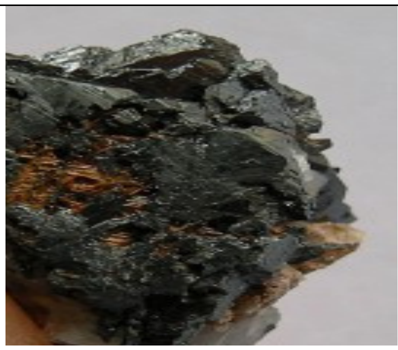
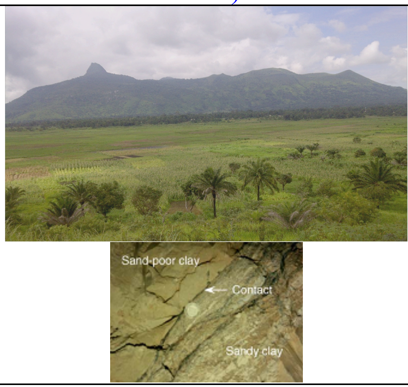
e) E-waste recycling

E-waste recycling involves the recovering of Au, Ag, Cu, Li, and Co, derived from the usage of electronic components (Nowakowsky, 2017; Xavier *et al.*, 2023). This activity is often considered as urban mining, and, according to Zhang *et al.* (2019), sustainable urban development is facing two main challenges: (i) the scarcity of primary resource which increases the demand, (ii) urbanization and industrialization which increases waste generation and environment concerns. The E-waste recycling also refers to "circular economy moving" which considers the use of by-products as secondary resources (Kirchherr *et al.*, 2017). Activities related to E-waste recycling are still limited in Cameroon.

III. Industries related to mineral resources and materials engineering

According to a study performed by the Cameroon National Institute of Statistic in 2018, the total number of modern companies in Cameroon was estimated to 34688, of which 1.0% from the primary sector, 9.5% from the secondary sector and 89.5% from the tertiary sector. The total turnover estimated at 12 655 billion FCFA of which 2.4% from the primary sector and 32.3% for the secondary sector.

Photos of some mineral available in Cameroon are presented in **Figure 2**

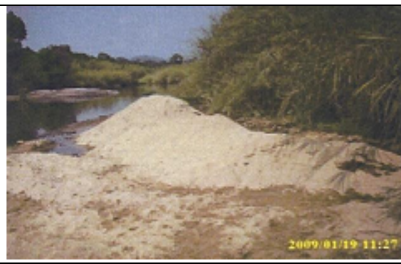
		
Diamond from Mobilong (East) (Tita, 2020)	Rutile from Akonolinga (Tita, 2020)	Sapphire from Cameroon[7]
		
Kyanite Nanga-Eboko[8]	Kaolin from Mayouom (Njoya, 2006)	Kaolin from Mankon (A Nzeukou Nzeugang *et al.*, 2018)
		
Feldspath from Ina, centre region (Soualiou, 2014)	Feldspath from Boboyo (Mipromalo, 2013)	Syenite from Eboundja (Mipromalo, 2011)
		
Clay from Ebebda (Nzeukou, 2014)	Clay from Bomkoul area (Mipromalo, 2011)	Clay from Monoun (Bomeni, 2019)

[7] Exploitation minière : le sous-sol camerounais compte plus de 4 variétés de pierres de couleurs (ecomatin.net), consulted on 30 August 2022

[8] Un gisement d'environ 200 000 tonnes de disthène découvert dans la région du Centre - Camerounactuel, consulted on 30 August 2022

Pouzzolan Bangwe-Benakuma Menchum (Philémon et al., 2016a)

Marble from Figuil (Mipromalo, 2019)



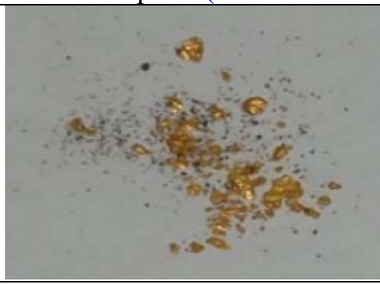
Sand from Akong river –Ako-Donga Mantum (NW region) (Mipromalo, 2019)

Quarry of basalt and industriel production unit of gravels at Grass Camp-Widikum-Momo (NW region) (Philémon et al., 2016a)

Bauxite from Minim Martap[9]

Cobalt-nickel-manganese from Nkamoua[10]

Iron from Bipindi (Geocam Mining)[11]



Gold in quartz veins (Viamba permit of BOCOM) (Penaye, 2013)

Gold from East Region (Tita, 2020)

Figure 2: Photos of some mineral available in Cameroon

The main companies involved in materials science using local minerals in Cameroon are classified in the secondary sector and include ALUCAM, CIMENCAM and other cement companies and SOCAVER. ALUCAM works in the production and transformation of primary aluminium through the three processes of electrolysis, rolling and lacquering, with a current nominal production capacity of

[9] Exploitation minière. Canyon Resources investit 6 milliards dans la Bauxite de Minim-Martap | cameroon-report.com, consulted on 30 August 2022

[10] Exploitation minière. Canyon Resources investit 6 milliards dans la Bauxite de Minim-Martap | cameroon-report.com , consulted on 30 August 2022

[11] FIELD PHOTOS (geocammining.africa), consulted on 30 August 2022

100,000 tons per year[12]. However, alumina raw material used by ALUCAM is still imported from other countries, while the benefit on the trade balance of the country would have been great if the local bauxite extraction had priority. The northern plant of Cimencam in Cameroon produces 150. 000 tons of clinkers per year. A new production line was inaugurated in this company on October 14, 2021, increasing the company production from 150.000 to 500.000 tons of clinker per year by 2023[13]. This company also has a plant in Douala and Yaoundé, but cement produced in these plants is from exported clinker, as the case for other cement compagnies installed in Cameroon (CIMAF, Dangote cement, Holcim, Egin, Mboka, MIRA Cement and Eren Holding group). Socaver is a subsidiary of the leading Cameroon brewery, SABC "Société Anonyme des Brasseries du Cameroun" specialized in the manufacture of hollow glass, with two furnaces producing 55,000 tons of molten glass annually. Socaver markets nearly 100 products brands including decorated and undecorated bottles, bottles pots. and jars[14]. Socaver is the only glass factory in Cameroon and all the Central Africa region. Socaver uses sand from Manoka in the littoral region of Cameroon as raw material. There is no company producing flat glasses which are still all imported. There is also lack of companies producing ceramic building materials like floor tile, and sanitary porcelain, the local market being supplied with imported materials, with related negative impact on the trade balance. In the domain of stones, SOMARC, founded in 2002, is one of the economic players in Cameroon who ambitioned to produce and process on site, specialized marbles - stones – granites. According to the Ministry of Mine and Technological Development (MINIMIDT)[15], Gaoda International Investment Trading Sarl, located in Nyom II (Edimi) in the district of Yaoundé 1er, recently inaugurated, can be considered as the first factory of its kind specialized in the transformation of stones into modern building materials in Cameroon. This company has planned a production of about 5000 tons/day, for an investment cost of 4.5 billion FCFA. Other companies dealing with minerals include NATH MINING, which markets online precious and fine stones from artisanal mining. Products are: cut and raw amethysts, citrine, blue sapphires, blue green sapphires, aquamarines, tourmalines, kyanites, garnets, emeralds, rubies, quartz, topazes, etc.[16]

IV. Research activities on materials engineering

There is currently eleven (11) state Universities in Cameroon namely, University of Bamenda, University of Buea, University of Douala, University of Maroua, University of Ngaoundéré, University of Yaoundé I, University of Yaoundé II, University of Bertoua, University of Ebolowa, and the University of Garoua. Apart from the University of Yaoundé II which is focused only on law and economic studies, and the Universities of Ebolowa, Bertoua and Garoua which have been recently created, the seven (07) other states Universities have been running programs and research activities related to materials engineering. Besides the conventional state universities, research activities on materials engineering are also carried out by some structures of Ministry of Scientific Research and Innovation like MIPROMALO, IRGM and IRAD, and a few private universities. These research activities are performed in many fields including building applications, animal husbandry and

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[12] https://www.alucam.cm/the-company/historical/ , consulted on 30.07.2022
[13] https://www.cimencam.com/fr/pose-de-la-premiere-pierre-de-la-nouvelle-ligne-de-production-de-clinker-et-de-ciment-de-cimencam-a , consulted on 08.08.2022
[14] https://www.lesboissonsducameroun.com/fr/nous-connaitre/le-groupe-sabc-en-bref/socaver, consulted on 08.08.2022
[15] https://www.minmidt.cm/ , consulted on 08.08.2022
[16] https://nath-mining.com/ , consulted on 08.08.2022

agricultural application, adsorbents, purification materials and materials for electrochemistry application.

a) Building application

A substantial number of research works have been carried out on the development of building materials from local resources. These included the valorisation of clays in the development of building ceramics (Bomeni *et al.,* 2018; Kagonbé *et al.,* 2021; Ndjigui *et al.,* 2016; Njoya *et al.,* 2017; Nzeugang Nzeukou *et al.,* 2013; Tsozué *et al.,* 2017; Ngon Ngon *et al.,* 2012), the development of alkali activated materials from clays (Elimbi *et al.,* 2011; Kenne Diffo *et al.,* 2015; Njoya *et al.,* 2016), volcanic ashes (Lemougna *et al.,* 2018; Patrick Ninla Lemougna *et al.,* 2014; Patrick N. Lemougna *et al.,* 2014; Tiffo *et al.,* 2021), laterites (Kaze *et al.,* 2021; Lemougna *et al.,* 2017; Rodrigue Kaze *et al.,* 2021), the development of acid based inorganic polymer cement from various local resources (Bewa *et al.,* 2020; Djon Li Ndjock *et al.,* 2022, 2021), the development of pozzolanic cements from local clays, limestone and rice hush ashes (Bayiha *et al.,* 2019; Billong *et al.,* 2020, 2011). The results of these research activities indicate that local mineral resources are of great potential for the development of various building materials. The use of locally produced building materials is also encouraged by the Prime Minister circular n°002/cab/pm of 12 march 2007 promoting the use of local materials in public buildings. However, many research works on building materials remain at the laboratory level. For instance, the sector of residential buildings is mainly dominated by concrete blocks in big cities. Fired bricks, compressed earth blocks, dimensioned stones and earth construction are also used as local building materials in some parts of the country.

b) Electrochemistry application

Electrochemistry is defined as the science enabling the transformation of matter using electricity (Njine-Bememba and Seumo Tchekwagep, 2022). Research activities in electrochemistry in Cameroon include the development of corrosion inhibiting materials (Tchoumene *et al.,* 2022; Wamba-Tchio *et al.,* 2022), the valorization of local materials for the development of electrochemical sensors and molecular electrochemistry as well as the use of electrochemistry as the main analytical method for the characterization of materials such as smectite and kaolinite clay minerals, lignocellulosic materials and double lamellar hydroxides (Deffo *et al.,* 2021; Mbouguen *et al.,* 2007; Ngassa *et al.,* 2014; Njine-Bememba and Seumo Tchekwagep, 2022; Tcheumi *et al.,* 2019). The physical and chemical properties of these materials are exploited for the removal of pollutants including heavy metals, dyes and pesticides. Additionally, some of these materials present interesting properties for an improvement of conventional electrodes such as glassy carbon, gold and graphite electrodes (Njine-Bememba and Seumo Tchekwagep, 2022).

c) Adsorbent and purification materials

Due to anthropogenic activities including mining, agricultural and industrial activities, the concentration of some hazardous elements into the global environment has been increased (Ano *et al.,* 2023; Akpakpan *et al.,* 2023; Ntakiyiruta *et al.,* 2023). Therefore, there has been many research activities performed in the development of purification materials using local resources. For instance, an efficient low cost and water defluoridation filter was developed using filtration layers made of local materials consisting of a sequence of gravel, bone-char and sand (Djousse Kanouo *et al.,* 2020). Clay based ceramic composite materials with hydraulic permeability were also elaborated using sawdust as pore forming agent to design ceramic filters (Youmoue *et al.,* 2017). Natural volcanic ash from Mount Cameroon was investigated by synchrotron radiation x-ray absorption spectroscopy for a potential use to remove Fe^{3+} ions from aqueous solutions in water treatment application (Thiodjio Sendja *et al.,* 2021). Many other studies related to the development of purification materials include the use of local clays for the removal of dye (Dobe *et al.,* 2022), ceramic membrane from local clay, coconut husks and eggshell for the retention of Escherichia coli bacteria (Kamgang-Syapnjeu *et al.,* 2020), local Egusi Seed Shells for the removal of nitrate ions from aqueous solution (Lekene *et al.,* 2021, 2018).

d) Animal husbandry and agricultural application

Minerals are used in modern agriculture as nutritionally important for crops, poultry, and animals. Indeed, the absorption and formation of organic compounds from these minerals are basic to almost all forms of life (Kilmer, 1979). Research activities on the use of local mineral resources for animal husbandry and agricultural application included the use of lime to reduce the negative impact of aluminum on soil fertility (Yerima *et al.,* 2020). Liming materials were also observed to be efficient in fishing farms for different purposes, including neutralizing acidity, increasing total alkalinity, disinfection of ponds and prevention of invasive wild species (Bouelet Ntsama *et al.,* 2018). Limestone from Mintom in the South Cameroon was also found potentially suitable for agricultural amendments (Philémon *et al.,* 2016b). Furthermore, application of finely ground basalts on impoverished soil (oxisoils) and monitoring of changes in physicochemical properties and especially for plants requiring alkalis and alkaline earth was done in Ngaoundere (Adoulko *et al.,* 2021). The fertilizing effect of vivianite (a phosphorus rich mineral) on the growth and yield of the bean plant ‘‘Phaseolus vulgaris’’ was assessed in Ngaoundéré (Fodoué *et al.,* 2015). The overall results indicate that vivianite can be used to enhance the bean crop yield and is therefore a good alternative to chemical fertilizers commonly used. Amendment of sandy soils by swelling clay materials was observed to be a promising solution to improve their fertility and enhanced crop yield. These swelling clay materials, characterized by high smectite contents, might also constitute an interesting alternative friendly fertilizer to the expensive chemical fertilizers often used (Simon Djakba and Jean Pierre, 2014).

e) Other applications

Other research activities in materials engineering include the valorization of biomass into biochar for energy or purification applications (Bot *et al.,* 2022; Djomdi *et al.,* 2021; Sarantopoulos e*t al.,* 2009; Sessa *et al.,* 2021). For instance, in a study of sawmill residue conversion by thermochemical process into biochar, it was observed a high concentration of carbon from 500°C meanwhile a heating rate from 0.1 to 70°C was observed to be marginal in the biochar yield; the possible application of the prepared biochar being solid fuel, soil amendment and carbon sequestration (Sessa et al., 2021). Other studies also include the use of laterite in the preparation of efficient (photo) catalyst for plasma oxidation of organic pollutant (Tarkwa *et al.,* 2019) and the use of natural kaolinite from Mayoum (a locality situated at the West region of Cameroon) for the production of oxide catalysts using the chemistry of gliding arc atmospheric plasma in humid air (Tiya-Djowe *et al.,* 2019).

V. Challenges and prospects

Many large companies in Cameroon are only considering external laboratories for research development on materials engineering related to their activities. This reduces the possibilities for private support and funding from industries to the universities. On the other hand, laboratory facilities are limited and need to be improved and modernized for a better contribution of local research institutions on the materials science development. There is a lot to be done for an industrial production of building materials from locally available resources. The market of building materials like ceramic floor tile and flat glasses is still exclusively dominated by imported materials, despites the effectiveness of suitable sand deposits for flat glasses and clay deposits for the floor tiles. Besides, research and industrial companies for high tech materials such as semi-conductors, photovoltaic solar cells, glasses for cell phone and other electronic applications, high tech ceramic for aeronautic, biomedical and electrotechnical application remain scarce in the country. The **Figure 3** present the importation of some inorganic materials in 2020.

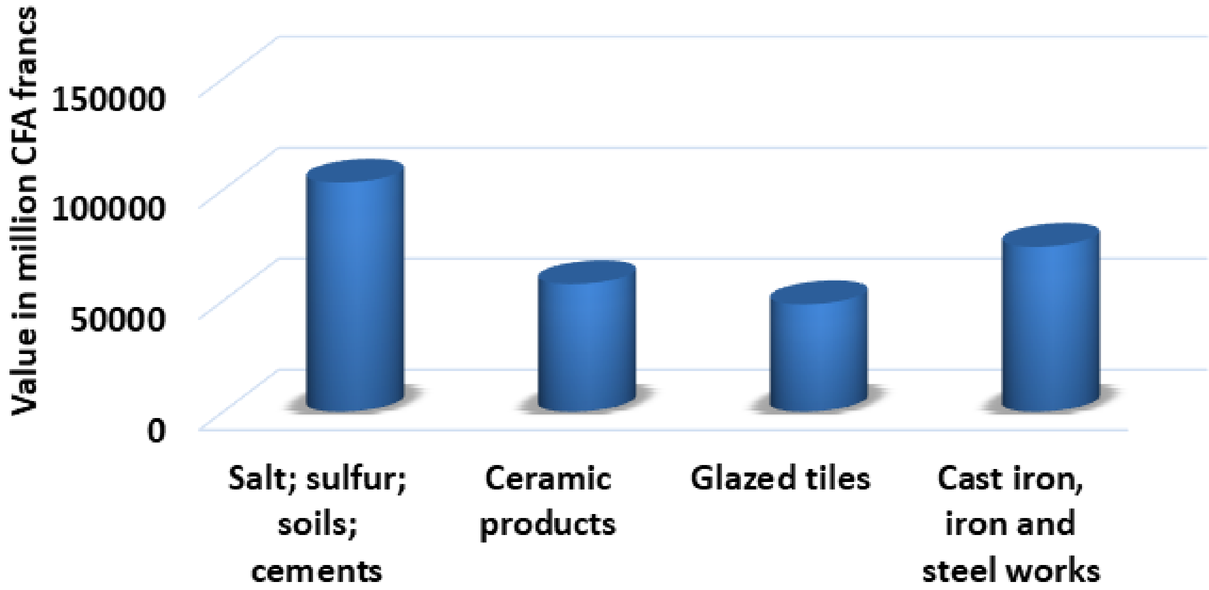

Figure 3. Information on some imported materials in 2020 from the Cameroon National Institute of Statistics[17]

Some potential applications of the mineral resources presented in **Table 2** are showing that there is still many areas of research and valorization activities in materials engineering to be performed from the Cameroun mineral resources. Information in **Figure 3** is showing that the country is losing a lot of money with importation of materials related to materials engineering industry, due to limited development of the country in the field. This has a negative effect on the country trade balance currently estimated at -744 billion FCFA deficit. Hence, it would be of interest for the government to increase the funding opportunities encouraging both research innovation and industrial development related to materials engineering. In light of information on country statistics related to imports/exports, regular meetings between companies, universities/research institutions and government should be established to implement better strategies for imports' reduction and country's development. In addition to that, international collaboration for technology transfer in various field of materials engineering should be encouraged and supported. For instance, some programs aiming to reduce importations, including scholarships to young Cameroonians for training in specific engineering fields abroad, followed by funding for developing start-ups in related areas could be implemented.

[17] COMMERCE EXTERIEUR DU CAMEROUN EN 2020, Une Publication du Département des Synthèses Économiques © INS, Juillet 2021 , Web: https://ins-cameroun.cm

Table 2: Some potential use of mineral resources

Mineral resources	Potential industrial applications/ research area to be explored
Iron	Steel and reinforcing steel, beams, angles, flat irons and machine wires which are intermediate products used to manufacture nails, smooth irons and screws
Cobalt/ Nickel/ Manganese	✓ Nickel is used in many industrial and consumer products (stainless steel, alnico magnets, coinage, rechargeable batteries, electric guitar strings, microphone capsules, plating on plumbing fixtures and special alloys). ✓ Cobalt is used in lithium-ion batteries, in the manufacture of magnetic, wear-resistant and high-strength alloys. Manganese is used for industrial alloy (stainless steels). It improves strength, workability, and resistance to wear
Diamond	Jewellery
Rutile /Anatase	Jewellery Pigments Sensors, photocatalysis Paints aircraft cockpits. Plastics, ink, coatings, paper, rubber, chemical fibber, chemical, ceramics, pharmaceutical, food, and some further industries
Kyanite	Refractory equipment and products Automotive and railroad industries
Tin	Household utensils
Kaolin	Porcelain, refractory industry Paper industry Cement and glass Fibber industries
Talc	Plaster making, Reinforcing filler Prosthesis in dental surgery
Quartz/ quartzite	Abrasive, Glassware, Silicon for various applications including semiconductor and photovoltaic solar cells.
Feldspar	Flux in glassmaking, ceramic and glaze production Fillers for plastics, Abrasives and hardcore aggregates, Coating of welding electrodes
Clay	Floor and roofing tile, fired brick, decorative ceramics, high tech ceramics, porcelain, Ecological Paints Medicine Geo-polymer cements Pharmaceutical products Thermal energy storage materials Absorbents Catalysts
Pouzzolana	Cement Soil amendment Soil drainage
Limestone	Cement, lime, paint, chalk
Marble	Decoration, Lime
Sand	Cement, Glasses for various common and high-tech applications, Aggregates, Soil amendment, Abrasives, paints, Silicon for photovoltaic solar cell, for semi-conductor in solid state devices in the computer, mobiles and other microelectronics industries.
Gneiss, granite, basalt, marble, etc.	Dimensioned Stones of ballast for railway roads, Foundation, Road works, Waterproofing Concrete production, High tech basalt fibre production for various technical applications.

VI. Conclusion

Cameroon has a huge potential of mineral resources, including iron, rutile, gold, nickel and cobalt, bauxite, diamond, limestone, marble, sand, clay and aggregates. However, these resources are still poorly exploited, with a contribution of less than 1% in the Gross Domestic Product, despite some government efforts and some ongoing research activities. These mineral resources are of great potential for industrial development of the country with possibility to serve as raw materials for the manufacturing of various products including semiconductors, photovoltaic solar cells, paints, glasses for electronic and building application, steels, ceramics refractories, etc., most of them being still exclusively imported. The effectiveness of such valorization will have a positive impact on the trade balance, job creation and the overall country development. Government should hence put more effort in improving research facilities in the Universities and research institutions as well as research funding for innovative projects related to materials engineering for research and start-up. In light of information on country statistics related to imports/exports, regular meetings between companies, universities/research institutions and government should be established to implement better strategies for imports' reduction, job creation in the field of materials engineering and country's development. Applying such strategy will beneficiate to Cameroon and countries with similar context.

References

A. Nzeukou Nzeugang, M. El Ouahabi, B. Aziwo, J.R. Mache, H.S. Mefire Mounton, N. Fagel, (2018). Characterization of kaolin from Mankon, northwest Cameroon. *Clay Minerals,* 53, 563–577. https://doi.org/10.1180/clm.2018.45

Adoulko D., Basga, S.D., Tchameni, R., Nguetnkam, J.P. (2021). The Influence of Basalt Powder on the Physicochemical Properties of Impoverished Oxisoils from Ngaoundéré (Adamawa - Cameroon). *International Journal of Plant & Soil Science* 33, 307–315. https://doi.org/10.9734/ijpss/2021/v33i2430782

Agyingi C.M., Manga V.E., Epanty, A.F., Lordon, A.D., Ngalla, N., A, Taboko, Wotanie, V.L. (2009). Coarse-grained rutile from regolith in Ebensuk west of Tinto, Cameroon. *J. Geol. Min. Res.* 12. https://doi.org/10.5897/JGMR2020.0345

Akpakpan A.E., Inam, E.J. and Itoro E. U., (2023). Preparation, Characterization and Application of Soda Lignin and its Ester Derivatives as Adsorbents in the Adsorption of Pb^{2+} and Cd^{2+} from wastewater. *J. Mater. Environ. Sci.*, 14, Issue 1, 82-96

Anderson K.F.E., Wall, F., Rollinson, G.K., Moon, C.J., (2014). Quantitative mineralogical and chemical assessment of the Nkout iron ore deposit, Southern Cameroon. *Ore Geology Reviews* 62, 25–39. https://doi.org/10.1016/j.oregeorev.2014.02.015

Ano J., Koné H., Yapo N. S., Drogui P., Yao K. B., Adouby K. (2023). Removal of copper and lead by electrocoagulation process: effects of experimental parameters and optimization with full factorial designs, *J. Mater. Environ. Sci.*, 14(2), 173-183.

Bayiha B.N., Billong, N., Yamb, E., Kaze, R.C., Nzengwa, R., (2019). Effect of limestone dosages on some properties of geopolymer from thermally activated halloysite. *Construction and Building Materials* 217, 28–35. https://doi.org/10.1016/j.conbuildmat.2019.05.058

Betsi T.B., Ngo Bidjeck Bondje L.M., Mvondo H., Yannick Mama Nga L.N., Molotouala C.A., McFarlane C., (2020). Rutile LA-ICP-MS U–Pb geochronology and implications for tectono-metamorphic evolution in the Yaoundé Group of the Neoproterozoic Central African Orogeny. *Journal of African Earth Sciences* 171, 103939.

https://doi.org/10.1016/j.jafrearsci.2020.103939

Bewa C.N., Tchakouté, H.K., Banenzoué, C., Cakanou, L., Mbakop, T.T., Kamseu, E., Rüscher, C.H., (2020). Acid-based geopolymers using waste fired brick and different metakaolins as raw materials. *Applied Clay Science* 198, 105813. https://doi.org/10.1016/j.clay.2020.105813

Billong N., Boubakar, L., Bayiha, B.N., Njimbouombouo, S.M., Melo, U.C., Oti, J., Kinuthia, J., (2020). An investigation on the suitability of hydrated building lime from travertine limestone outcrop of Bogongo, South West of Cameroon. *Case Studies in Construction Materials,* 13, e00369. https://doi.org/10.1016/j.cscm.2020.e00369

Billong N., Melo, U.C., Kamseu, E., Kinuthia, J.M., Njopwouo, D., (2011). Improving hydraulic properties of lime–rice husk ash (RHA) binders with metakaolin (MK). Construction and Building Materials 25, 2157–2161. https://doi.org/10.1016/j.conbuildmat.2010.11.013

Biney E., Biney, N., Dadzie, I., Harris, E., Quartey, G.A., Asare, Y.M., Bessah, E., Forkuo, E.K., (2022). Impact of mining on vegetation cover: A case study of Prestea Huni-Valley municipality. *Scientific African,* 17, e01387. https://doi.org/10.1016/j.sciaf.2022.e01387

Bisse S.B., Ekomane E., Eyong J.T., Ollivier V., Douville E., Maffo Nganne M.J., Ekoko eric B., Bitom L.D., *(*2018*)*. Sedimentological and geochemical study of the Bongongo and Ngol travertines located at the Cameroon Volcanic Line. *Journal of African Earth Sciences*, 143, 201–214. https://doi.org/10.1016/j.jafrearsci.2018.03.028

Boaka à Koul, M.L., Yongue-Fouateu, R., Ndjigui, P.-D., *(*2010). The alluvial sapphire profiles of Mayo Kewol placer in the Adamawa region (North-Cameroon): Granulometric and mineralogical features. *Journal of African Earth Sciences,* 56, 121–126. https://doi.org/10.1016/j.jafrearsci.2009.05.010

Bomeni I.Y., (2019). Caracterisation, estimation et valorisation des argiles de bangourain (noun, ouest cameroun). Ph.D thesis University of Dschang, 173p.

Bomeni I.Y., Kenmoe, M.R., Nzeukou, A., Pirard, E., Wouatong, A.S.L., Fagel, N., (2022). Estimation of minerals content and alluvial clays deposit in the Monoun plain (West Cameroon) by geological and geostatistical method. *Arabian journal of Geosciences*, 15, 1774

Bomeni I.Y., Njoya A., Ngapgue F., Wouatong A.S.L., Yongue Fouateu R., Kamgang Kabeyene V., Fagel N. (2018). Ceramic with potential application of ngwenfon alluvial clays (noun, west cameroon) in building construction: Mineralogy, physicochemical composition and thermal behaviour. *Construction and Building Materials,* 182, 493–503. https://doi.org/10.1016/j.conbuildmat.2018.06.135

Bot B.V., Axaopoulos P.J., Sakellariou E.I., Sosso O.T., Tamba J.G. (2022). Energetic and economic analysis of biomass briquettes production from agricultural residues. *Applied Energy,* 321, 119430. https://doi.org/10.1016/j.apenergy.2022.119430

Bouelet Ntsama I.S., Tambe B.A., Tsafack Takadong J.J., Medoua Nama G., Kansci G. (2018). Characteristics of fish farming practices and agrochemicals usage therein in four regions of Cameroon. *The Egyptian Journal of Aquatic Research,* 44, 145–153. https://doi.org/10.1016/j.ejar.2018.06.006

Cédric B.B., Emile E., Thierry B.B., Patricienne Marie Carly N.B., Nkongho A.E., Eric, B.E., Falonne I.M., Diane T.M., Léandre O.E., Bertrant B.S. (2022). Trace element geochemistry and U–Pb ages of alluvial rutiles from a neoproterozoic coastal area, southwestern Cameroon: Implication for source rocks. *Journal of African Earth Sciences,* 185, 104399. https://doi.org/10.1016/j.jafrearsci.2021.104399

Deffo, G., Tonleu Temgoua R.C., Foukmeniok Mbokou S., Njanja E., Kenfack Tonlé I., Ngameni E. (2021). A sensitive voltammetric analysis and detection of Alizarin Red S onto a glassy carbon electrode modified by an organosmectite. *Sensors International,* 2, 100126. https://doi.org/10.1016/j.sintl.2021.100126

Djibril K.N.G., Cliford, T.B., Pierre, W., Magha, A., Kuma, C.J., Flore, T.D.J., (2017). Artisanal gold mining in Batouri area, East Cameroon: Impacts on the mining population and their environment. *Journal of Geology and Mining Research*, 9(1):1-8. https://doi.org/10.5897/JGMR2016.0263

Djomdi, Fadimatou, H., Hamadou, B., Nguela, L.J.M., Christophe, G., Michaud, P., (2021). Improvement of thermophysical quality of biomass pellets produced from rice husks. Energy *Conversion and Management,* X 12, 100132. https://doi.org/10.1016/j.ecmx.2021.100132

Djon Li Ndjock, B.I., Baenla, J., Yanne, E., Bike Mbah, J.B., Souaïbou, Elimbi, A., (2022). Effects of Al and Fe powders on the formation of foamed cement obtained by phosphoric acid activation of volcanic ash. *Materials Letters,* 308, 131147. https://doi.org/10.1016/j.matlet.2021.131147

Djon Li Ndjock, B.I., Robayo-Salazar R.A., Mejía de Gutiérrez, R., Baenla J., Mbey J.A., Cyr M., Elimbi A., (2021). Phosphoric acid activation of volcanic ashes: Influence of the molar ratio R = $(MgO + CaO) / P_2O_5$ on reactivity of volcanic ash and strength of obtained cementitious material. *Journal of Building Engineering,* 33, 101879. doi.org/10.1016/j.jobe.2020.101879

Djousse K., B.M., Fru Fonteh, M., Pindjou Ngambo, S., (2020). Development of a low cost household bone-char defluoridation filter. *Int. J. Biol. Chem. Sci.,* 14, 1921–1927. https://doi.org/DOI: 10.4314/ijbcs.v14i5.33

Dobe N., Abia, D., Tcheka, C., Tejeogue, J.P.N., Harouna, M., (2022). Removal of amaranth dye by modified Ngassa clay: Linear and non-linear equilibrium, kinetics and statistical study. *Chemical Physics Letters,* 801, 139707. https://doi.org/10.1016/j.cplett.2022.139707

Dongmo F.W.N., Yongue, R.F., Bolarinwa, A.T., Ngatcha, R.B., Fuanya, C., Kamga, M.A., (2019). Contribution to the Study of Bauxites' Formation in the Fongo-Tongo (Western Cameroon) Sites, in: Doronzo, D.M., Schingaro, E., Armstrong-Altrin, J.S., Zoheir, B. (Eds.), Petrogenesis and Exploration of the Earth's Interior. Springer International Publishing, Cham, pp. 241–244.

Elimbi A., Tchakoute, H.K., Njopwouo, D., (2011). Effects of calcination temperature of kaolinite clays on the properties of geopolymer cements. *Construction and Building Materials,* 25, 2805–2812. https://doi.org/10.1016/j.conbuildmat.2010.12.055

Emmanuel N.N., Rigobert, T., Anne, N., Roberto, S., André, P., Jérôme, B., (2013). Structure and petrology of Pan-African nepheline syenites from the South West Cameroon; Implications for their emplacement mode, petrogenesis and geodynamic significance. *Journal of African Earth Sciences,* 87, 44–58. https://doi.org/10.1016/j.jafrearsci.2013.07.008

Fodoué Y., Tchameni, R., Pénaye, J., (2015). Assessment of the Fertilizing effect of Vivianite on the Growth and yield of the Bean "phaseolus vulgaris" on Oxisoils from Ngaoundere (Central North Cameroon). *International Research Journal of Earth Sciences,* Vol. 3(4), 18-26.

Fuh C.G., (2013). Cameroon the destination of mining, Mining On Top: Africa. London Summit.

Gentry F.C., Tchakounte, N.J., Kundu, O.M., Tchop, J.L., Nkoumbou, C., (2021). Four Pan-African plutonic sets of the Colomines gold district (East-Cameroon): Petrogenesis, K-Ar dating and geodynamic significance. *Journal of African Earth Sciences,* 181, 104220. https://doi.org/10.1016/j.jafrearsci.2021.104220

Gleeson S.A., Butt, C.R.M., Elias, M., (2003). Nickel Laterites: A Review. *SEG Discovery* 1–18. https://doi.org/10.5382/SEGnews.2003-54.fea

Ibarra-Gutiérrez S., Bouchard J., Laflamme M., Fytas K., (2021). Assessing the potential of quebec lithium industry: Mineral reserves, lithium-ion batteries production and greenhouse gas emissions. *Resources Policy,* 74, 102371. https://doi.org/10.1016/j.resourpol.2021.102371

INS, (2022). Enquête Complémentaire à la quatrième Enquête Camerounaise Auprès des Ménages (EC-ECAM 4) : Monographie de la region du centre. Institut national de la statistique 103p.

Jude P.N., Jean Victor, K., Pierre, W., Anoh, N.O., Abasoh, M.E., Malick Rosvelt, D.M., Tabod, T.C., (2021). Petrographic, morpho-structural and geophysical study of the quartzite deposit in the central part of Pouma, Littoral-Cameroon. *Results in Geophysical Sciences,* 7, 100019. https://doi.org/10.1016/j.ringps.2021.100019

Kagonbé B.P., Tsozué, D., Nzeukou, A.N., Ngos, S., (2021). Mineralogical, physico-chemical and ceramic properties of clay materials from Sekandé and Gashiga (North, Cameroon) and their suitability in earthenware production. *Heliyon,* 7, e07608. https://doi.org/10.1016/j.heliyon.2021.e07608

Kamga M.A., Nzali S., Olatubara C.O., Adenikinju A., Akintunde E.A., Kemeng M.P., Nguimatsia F.W.D., Ndip E.A., Fuanya C., (2018). Sustainable development and environmental challenges in Cameroon's mining sector: A review. *JME* 9. https://doi.org/10.22044/jme.2017.6141.1429

Kamgang-Syapnjeu P., Njoya D., Kamseu E., Cornette de Saint Cyr L., Marcano-Zerpa A., Balme S., Bechelany M., Soussan L. (2020). Elaboration of a new ceramic membrane support from Cameroonian clays, coconut husks and eggshells: Application for Escherichia coli bacteria retention. *Applied Clay Science,* 198, 105836. https://doi.org/10.1016/j.clay.2020.105836

Kanouo N., Wang L., Kouske A., Yomeun S., Basua E. (2019). Petro-Geochemistry, Genesis and Economic Aspect of Syenitic and Mafic Rocks in Mindif Complex, Far North Cameroon, Central Africa. *International Journal of Geosciences* 10, 1081–1114. https://doi.org/10.4236/ijg.2019.1012062.

Kanouo N.S., Zaw, K., Yongue, R.F., Sutherland, F.L., Meffre, S., Njonfang, E., Ma, C., (2012). Detrital mineral morphology and geochemistry: Methods to characterize and constrain the origin of the Nsanaragati blue sapphires, south-western region of Cameroon. Journal of African Earth Sciences, 70, 18–23. https://doi.org/10.1016/j.jafrearsci.2012.05.002

Kaze C.R., Lecomte-Nana, G.L., Kamseu, E., Camacho, P.S., Yorkshire, A.S., Provis, J.L., Duttine, M., Wattiaux, A., Melo, U.C., (2021). Mechanical and physical properties of inorganic polymer cement made of iron-rich laterite and lateritic clay: A comparative study. *Cement and Concrete Research,* 140, 106320. https://doi.org/10.1016/j.cemconres.2020.106320

Kenne Diffo, B.B., Elimbi, A., Cyr, M., Dika Manga, J., Tchakoute Kouamo, H., (2015). Effect of the rate of calcination of kaolin on the properties of metakaolin-based geopolymers. *Journal of Asian Ceramic Societies,* 3, 130–138. https://doi.org/10.1016/j.jascer.2014.12.003

Kirchherr J., Reike D., Hekkert M. (2017). Conceptualizing the circular economy: an analysis of 114 definitions. Resour. Conserv. Recycl. Vol. 127, Pp 221-232

Kilmer V.J., (1979). Chapter 9 Minerals and Agriculture, in: Trudinger, P.A., Swaine, D.J. (Eds.), *Studies in Environmental Science.* Elsevier, pp.515–558. https://doi.org/10.1016/S0166-1116(08)71070-7

KPMG, (2014). Cameroon Country mining guide, strategy.

Lambiv Dzemua G., Gleeson S.A., Schofield P.F. (2013). Mineralogical characterization of the Nkamouna Co–Mn laterite ore, southeast Cameroon. *Mineralium Deposita* 48, 155–171. https://doi.org/10.1007/s00126-012-0426-3

Lekene R.B.N., Kouotou, D., Ankoro, N.O., Kouoh, A.P.-M.S., Ndi, J.N., Ketcha, J.M., (2021). Development and tailoring of amino-functionalized activated carbon based Cucumerupsi manni Naudin seed shells for the removal of nitrate ions from aqueous solution. J*ournal of Saudi Chemical Society,* 25, 101316. https://doi.org/10.1016/j.jscs.2021.101316

Lekene R.B.N., Nsami, J.N., Rauf, A., Kouotou, D., Belibi Belibi, P.D., Bhanger, M.I., Mbadcam, J.K., (2018). Optimization Conditions of the Preparation of Activated Carbon Based Egusi (Cucumeropsis mannii Naudin) Seed Shells for Nitrate Ions Removal from Wastewater. *American Journal of Analytical Chemistry,* 9, 439–463. https://doi.org/10.4236/ajac.2018.910034

Lemougna Patrick N., Chinje Melo, U.F., Delplancke, M.-P., Rahier, H., (2014). Influence of the chemical and mineralogical composition on the reactivity of volcanic ashes during alkali activation. *Ceramics International* 40, 811–820. https://doi.org/10.1016/j.ceramint.2013.06.072

Lemougna Patrick Ninla, Madi, A.B., Kamseu, E., Melo, U.C., Delplancke, M.-P., Rahier, H., (2014). Influence of the processing temperature on the compressive strength of Na activated lateritic soil for building applications. *Construction and Building Materials,* 65, 60–66. https://doi.org/10.1016/j.conbuildmat.2014.04.100

Lemougna P.N., Wang K., Tang Q., Nzeukou A.N., Billong N., Melo U.C., Cui X. 2(018). Review on the use of volcanic ashes for engineering applications. *Resources, Conservation and Recycling,* 137, 177–190. https://doi.org/10.1016/j.resconrec.2018.05.031

Lyonga D.I., Fuanya, C., Mounsi, F., Flaubert, G.Z., Abdoul, A., Tchatchoua, F.T.R., Venceslas, S.H., Ndi, N., Lyonga, A.M., Asangbeh, S.T., Fabian, B.S., Nlomngan, J.P.S., (2022). Bidzar Marble Tailing Characterization and Potential for Civil Engineering Works Northern Cameroon. *Earth Sciences*, 11, 4. https://doi.org/10.11648/j.earth.20221104.17

Mbouguen, J.K., Ngameni, E., Walcarius, A., (2007). Quaternary ammonium functionalized clay film electrodes modified with polyphenol oxidase for the sensitive detection of catechol. *Biosensors and Bioelectronics, 2*3, 269–275. https://doi.org/10.1016/j.bios.2007.04.008

Mipromalo (2019). Rapport d'étude relative au projet de création d'une unité industrielle de production des carreaux de marbre dans l'arrondissement de Figuil.

Mipromalo (2013). Rapport de mission effectué à Boboyo, 4p.

Mipromalo (2011). Rapport mission syenite nephelinique d'Eboundja (Mont des éléphants).

Moudioh C., Tamehe, L.S., Ganno, S., Nzepang Tankwa, M., Brando Soares, M., Ghosh, R., Kankeu, B., Nzenti, J.P., (2020). Tectonic setting of the Bipindi greenstone belt, northwest Congo craton, Cameroon: Implications on BIF deposition. *Journal of African Earth Sciences,* 171, 103971. https://doi.org/10.1016/j.jafrearsci.2020.103971

Mouliom S., Njoya, A., Fouateu, R., Kanouo, N., Mbila, D., Charlier, B., Fagel, N., (2022). Mineralogy, Petrography and Geochemistry of the Ina Syenite (Linté, Central Cameroon) as a Source of Industrial Feldspars. *Journal of Minerals and Materials Characterization and Engineering*, 10, 287–318. https://doi.org/10.4236/jmmce.2022.103022

Ndime E.N., Ganno S., Nzenti J.P. (2019). Geochemistry and Pb–Pb geochronology of the Neoarchean Nkout West metamorphosed banded iron formation, southern Cameroon. *International Journal of Earth Sciences,* 108, 1551–1570. https://doi.org/10.1007/s00531-019-01719-5

Ndjigui P.-D., Mbey, J.A., Nzeukou, A.N. (2016). Mineralogical, physical and mechanical features of ceramic products of the alluvial clastic clays from the Ngog-Lituba region, Southern Cameroon. J*ournal of Building Engineering,* 5, 151–157. https://doi.org/10.1016/j.jobe.2015.11.009

Nforba M., Kabeyene, V., Suh, C., (2011). Regolith Geochemistry and Mineralogy of the Mbalam Itabirite-Hosted Iron Ore District, South Eastern Cameroon. *Open Journal of Geology,* 1, 17–36. https://doi.org/10.4236/ojg.2011.12003

Ngassa G.B.P., Tonlé I.K., Walcarius A., Ngameni E. (2014). One-step co-intercalation of cetyltri-methylammonium and thiourea in smectite and application of the organoclay to the sensitive electrochemical detection of Pb(II). *Applied Clay Science*, 99, 297–305. https://doi.org/10.1016/j.clay.2014.07.014

Ngo Bidjeck Bondje L.M., Bineli Betsi, T., Mama Nga, L.N.Y., Ngo Belnoun, R.N., Molotouala, A.C., McFarlane, C., Bitom, L.D., (2020). Geochemistry of rutile from the Pan-African Yaoundé metamorphic group: Implications for provenance and conditions of formation. *Journal of African Earth Sciences*, 170, 103912. https://doi.org/10.1016/j.jafrearsci.2020.103912

Njine-Bememba C.B., Seumo Tchekwagep, P.M., (2022). Challenges of electrochemistry research in Central Africa: The case of Cameroon. *Current Opinion in Electrochemistry*, 31, 100861. https://doi.org/10.1016/j.coelec.2021.100861

Njoya A., (2006). Etude du gisement de kaolin de Mayouom (Foumban, Ouest Cameroun): géologie, minéralogie et géochimie. Thèse Doct. Univ. Yaoundé 1.

Njoya A., Nkoumbou, C., Grosbois, C., Njopwouo, D., Njoya, D., Courtin-Nomade, A., Yvon, J., Martin, F., (2006). Genesis of Mayouom kaolin deposit (western Cameroon). *Applied Clay Science,* 32, 125–140. https://doi.org/10.1016/j.clay.2005.11.005

Njoya, D., Elimbi, A., Fouejio, D., Hajjaji, M., (2016). Effects of two mixtures of kaolin-talc-bauxite and firing temperatures on the characteristics of cordierite- based ceramics. *Journal of Building Engineering*, 8, 99–106. https://doi.org/10.1016/j.jobe.2016.10.004

Njoya, D., Tadjuidje, F.S., Ndzana, E.J.A., Pountouonchi, A., Tessier-Doyen, N., Lecomte-Nana, G., (2017). Effect of flux content and heating rate on the microstructure and technological properties of Mayouom (Western-Cameroon) kaolinite clay based ceramics. *Journal of Asian Ceramic Societies* ,5, 422–426. https://doi.org/10.1016/j.jascer.2017.09.004

Nkoumbou, C., Njoya, A., Njoya, D., Grosbois, C., Njopwouo, D., Yvon, J., Martin, F., (2009). Kaolin from Mayouom (Western Cameroon): Industrial suitability evaluation. Applied Clay Science, 43, 118–124. https://doi.org/10.1016/j.clay.2008.07.019

Noel, E., Marcelin, M., Bekoa, A., 2014. Crustal Structure and Seismogenic Zone of Cameroon: Integrated Seismic, Geological and Geophysical Data. *Open Journal of Earthquake Research,* 3, 152–161. https://doi.org/10.4236/ojer.2014.34015

Nowakowski P., Pamuła T. (2020). Application of deep learning object classifier to improve e-waste collection planning. *Waste Management,* 109, 1-9.

Ntakiyiruta P., Mpawenayo P.Cl., Rucakumugufi D., Bigumandondera P., Ndikumana T., Vasel J.L. (2023). Removal of iron and manganese by aeration and coagulationflocculation in borehole water from the town of Rumonge (Burundi). *J. Mater. Environ. Sci*., 14(1), 141-152.

Nyobe J.M., Sababa E., Bayiga E.C., Ndjigui P.-D. (2018). Mineralogical and geochemical features of alluvial sediments from the Lobo watershed (Southern Cameroon): Implications for rutile exploration. *Comptes Rendus Geoscience*, 350, 119–129. doi:10.1016/j.crte.2017.08.003

Nzeugang Nzeukou, A., Fagel, N., Njoya, A., Beyala Kamgang, V., Eko Medjo, R., Chinje Melo, U., (2013). Mineralogy and physico-chemical properties of alluvial clays from Sanaga valley (Center, Cameroon): Suitability for ceramic application. *Applied Clay Science,* 83–84, 238–243. https://doi.org/10.1016/j.clay.2013.08.038

Nzeukou, A., Kamgang, V., Medjo, R., Melo, U., Njoya, A., Lemougna, P., Fagel, N., (2013). Industrial Potentiality of Alluvial Clays Deposits from Cameroon: Influence of Lateritic Clayey Admixture for Fired Bricks Production. *Journal of Minerals and Materials Characterization and Engineering,* 1. https://doi.org/10.4236/jmmce.2013.15037

Paul Mbih K., Meffre S., Yongue R.F., Kanouo N.S., Jay T. (2016). Chemistry and origin of the Mayo Kila sapphires, NW region Cameroon (Central Africa): Their possible relationship with the Cameroon volcanic line. *J. Afr. Earth Sci.,* 118, 263–273. doi:10.1016/j.jafrearsci.2016.03.004

Penaye, J., (2013). Premiers Résultats d'exploration Aurifère Du Permis Vaïmba, Nord Cameroun., Exposition & 1ère Conférence Internationale sur les mines au Cameroun.

Philémon, Z., Aubin, N., Melo, U., Richard, M., Azigui, N., Jean, N., (2016a). Typology of Local Construction Materials from the Adamawa and North-West Regions of Cameroon. *Geomaterials,* 50–59. https://doi.org/10.4236/gm.2016.62005.

Philémon, Z., Grelle, M., Philippe, S., (2016b). Physico-Chemical and Petrographic Characterization of Carbonated Rocks of Mintom (South-Cameroon) and Their Potential Uses. *International Journal of Geosciences,* 7, 775–783. https://doi.org/10.4236/ijg.2016.75059

Rodrigue Kaze, C., Ninla Lemougna, P., Alomayri, T., Assaedi, H., Adesina, A., Kumar Das, S., Lecomte-Nana, G.-L., Kamseu, E., Chinje Melo, U., Leonelli, C., (2021). Characterization and performance evaluation of laterite based geopolymer binder cured at different temperatures. *Construction and Building Materials,* 270, 121443. https://doi.org/10.1016/j.conbuildmat.2020.121443

Sarantopoulos I., Che F., Tsoutsos T., Bakirtzoglou V., Azangue W., Bienvenue D., Ndipen F.M. (2009). An evaluation of a small-scale biodiesel production technology: Case study of Mango'o village, Center province, Cameroon. *Physics and Chemistry of the Earth*, Parts A/B/C 34, 55–58. https://doi.org/10.1016/j.pce.2008.07.005

Sessa F., Veeyee K.F., Canu P. (2021). Optimization of biochar quality and yield from tropical timber industry wastes. *Waste Management*, 131, 341–349. doi.org/10.1016/j.wasman.2021.06.017

Simon Djakba, B., Jean Pierre, N., (2014). Fertilizing Effect of Swelling Clay Materials on the Growth and Yield of Bean "Phaseolus vulgaris" on the Sandy Ferruginous Soils from Mafa Tcheboa (North Cameroon, Central Africa). *International Journal of Plant & Soil Science,* 5, 10–24. https://doi.org/10.9734/IJPSS/2015/13180

Soh Tamehe, L., Djamo Mbenjo, F.A., Ganno, S., Nzenti, J.P., (2020). Geochemical characteristics of the Mamelles iron ore deposit from the Ntem Complex, Congo craton, SW Cameroon. 36th *International Geological Congress*: New Delhi, India.

Soualiou, N., (2014). Pétrographie et caractérisation des syénites de Linté comme une source potentielle de feldspaths à usage industriel. Master thesis University of Yaoundé 1.

Stendal, H., Toteu, S.F., Frei, R., Penaye, J., Njel, U.O., Bassahak, J., Nni, J., Kankeu, B., Ngako, V., Hell, J.V., (2006). Derivation of detrital rutile in the Yaoundé region from the Neoproterozoic Pan-African belt in southern Cameroon (Central Africa). *Journal of African Earth Sciences*, 44, 443–458. https://doi.org/10.1016/j.jafrearsci.2005.11.012

Sylvestre, G., Evine Laure, N.T., Gus Djibril, K.N., Arlette, D.S., Cyriel, M., Timoléon, N., Jean Paul, N., (2017). A mixed seawater and hydrothermal origin of superior-type banded iron formation (BIF)-hosted Kouambo iron deposit, Palaeoproterozoic Nyong series, Southwestern Cameroon: Constraints from petrography and geochemistry. *Ore Geology Reviews*, 80, 860–875. https://doi.org/10.1016/j.oregeorev.2016.08.021

Tarkwa, J.-B., Acayanka, E., Jiang, B., Oturan, N., Kamgang, G.Y., Laminsi, S., Oturan, M.A., (2019). Highly efficient degradation of azo dye Orange G using laterite soil as catalyst under irradiation of non-thermal plasma. Applied Catalysis B: Environmental, 246, 211–220. https://doi.org/10.1016/j.apcatb.2019.01.066

Tchamdjou, W.H.J., Cherradi, T., Abidi, M., (2015). Valorisation of natural pozzolan of "Djoungo" (Cameroon) as lightweight aggregate for lightweight concrete. First International Conference on Science, *Engineering & Environment,* 1, 381–386.

Tcheumi, H.L., Tassontio, V.N., Tonle, I.K., Ngameni, E., (2019). Surface functionalization of smectite-type clay by facile polymerization of β-cyclodextrin using citric acid cross linker: Application as sensing material for the electrochemical determination of paraquat. *Applied Clay Science,* 173, 97–106. https://doi.org/10.1016/j.clay.2019.03.013

Tchoumene, R., Kenne Dedzo, G., Ngameni, E., (2022). Intercalation of 1,2,4-triazole in methanol modified-kaolinite: Application for copper corrosion inhibition in concentrated sodium chloride aqueous solution. *Journal of Solid State Chemistry,* 311, 123103. https://doi.org/10.1016/j.jssc.2022.123103

Teutsong, T., Temga, J.P., Enyegue, A.A., Feuwo, N.N., Bitom, D., (2021). Petrographic and geochemical characterization of weathered materials developed on BIF from the Mamelles iron ore deposit in the Nyong unit, South-West Cameroon. *Acta Geochimica*, 40, 163–175. https://doi.org/10.1007/s11631-020-00421-7

Thiodjio Sendja, B., Medellin Castillo, N.A., Loredo Portales, R., Tchounang Kouonang, S., Labrada Delgado, G.J., Carranza Álvarez, C., Olivi, L., (2021). Iron adsorption in Cameroon volcanic ashes insights from x-ray absorption spectroscopy. *Physica B: Condensed Matter*, 617, 413128. https://doi.org/10.1016/j.physb.2021.413128

Tiffo, E., Belibi, P.D.B., Mbah, J.B.B., Thamer, A., Pougnong, T.E., Baenla, J., Elimbi, A., (2021). Effect of various amounts of aluminium oxy-hydroxide coupled with thermal treatment on the performance of alkali-activated metakaolin and volcanic scoria. *Scientific African* 14, e01015. https://doi.org/10.1016/j.sciaf.2021.e01015

Tita, A., (2020). Minerals in Cameroon. 27p. Conference-ESOGU-CHTP.

Tiya-Djowe, A., Acayanka, E., Mbouopda, A.P., Boyom-Tatchemo, W., Laminsi, S., Gaigneaux, E.M., (2019). Producing oxide catalysts by exploiting the chemistry of gliding arc atmospheric plasma in humid air. *Catalysis Today,* 334, 104–112. https://doi.org/10.1016/j.cattod.2019.01.008

Tonje, J.C., Ndjigui, P.-D., Nyeck, B., Bilong, P., (2014). Geochemical features of the Matomb alluvial rutile from the Neoproterozoic Pan-African belt, Southern Cameroon. *Geochemistry* 74, 557–570. https://doi.org/10.1016/j.chemer.2013.09.002

Tsozué, D., Nzeugang, A.N., Mache, J.R., Loweh, S., Fagel, N., 2017. Mineralogical, physico-chemical and technological characterization of clays from Maroua (Far-North, Cameroon) for use in ceramic bricks production. *Journal of Building Engineering,* 11, 17–24. https://doi.org/10.1016/j.jobe.2017.03.008

Wamba-Tchio, O.R., Pengou, M., Teillout, A.-L., Baumier, C., Mbomekallé, I.M., De Oliveira, P., Nanseu-Njiki, C.P., Ngameni, E., (2022). Electrochemical study and experimental simulation of the synergistic effect of a formulation based on Ficus pumila Linn. Leaves extract and zinc sulfate on the XC38 steel corrosion inhibition in NaCl solution. *Journal of Electroanalytical Chemistry,* 919, 116553. https://doi.org/10.1016/j.jelechem.2022.116553

Weng, L., Margules, C., (2022). Challenges with formalizing artisanal and small-scale mining in Cameroon: Understanding the role of Chinese actors. *The Extractive Industries and Society* 9, 101046. https://doi.org/10.1016/j.exis.2022.101046

Woguia, D.L., Fagel, N., Pirard, E., Gourfi, A., Ngo bidjeck, L.M., El ouahabi, M., (2021). Talc schist deposits from central Cameroon: Mineralogical and physico-chemical characterization. *Journal of African Earth Sciences* 178, 104182. https://doi.org/10.1016/j.jafrearsci.2021.104182

Wouatong A.S.L., Kenmoe O.R.M., Ngapgue F., Katte V., Kamgang V. (2017). A Geological and Physico-Mechanical Characterization of Marble of the Bidzar Quarry North-Cameroon. *Current Journal of Applied Science and Technology*, 19(5), 1–11. https://doi.org/10.9734/BJAST/2017/30421

Xavier L.H., Ottoni M., Abreu L.P.P. (2023). Review: A comprehensive review of urban mining and the value recovery from e-waste materials. *Resour. Conserv. Recycl.*, 190, 106840. https://doi.org/10.1016/j.resconrec.2022.106840

Yamb E., Bayiha B., Billong N., Robertovna S. (2016). Compatibility of Bidzar limestone and Figuil clay (northern Cameroon) for the production of portland clinker. *International Journal of Materials Engineering and Technology,* 15, 75–92.http://dx.doi.org/10.17654/MT015010063

Yerima, B.P.K., Enang, R.K., Kome, G.K., Van Ranst, E., (2020). Exchangeable aluminium and acidity in Acrisols and Ferralsols of the north-west highlands of Cameroon. *Geoderma Regional,* 23, e00343. https://doi.org/10.1016/j.geodrs.2020.e00343

Yongue-Fouateu, R., Ghogomu, R.T., Penaye, J., Ekodeck, G.E., Stendal, H., Colin, F., (2006). Nickel and cobalt distribution in the laterites of the Lomié region, south-east Cameroon. *Journal of African Earth Sciences,* 45, 33–47. https://doi.org/10.1016/j.jafrearsci.2006.01.003

Youmoue M., Fongang R.T.T., Sofack J.C., Kamseu E., Melo U.C., Tonle I.K., Leonelli C., Rossignol S. (2017). Design of ceramic filters using Clay/Sawdust composites: Effect of pore network on the hydraulic permeability. *Ceramics International,* 43, 4496–4507. doi:10.1016/j.ceramint.2016.12.101

Zhang M., Li B. (2019). Urban Mining: Characterization and Recycling of Solid Wastes. *Journal of the Minerals, Metals & Materials Society*, 71(10), doi: 10.1007/s11837-019-03721-3

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