Carbonate resources of Cameroon and potential applications.

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ABSTRACT

Carbonate deposits are known to occur in three geologic settings in Cameroon including sedimentary, igneous and metamorphic terrains. These carbonates include limestones, dolomitic limestones, marl, marble, travertine and carbonatites. Sedimentary carbonate deposits outcrop in the Douala basin in the Mungo valley, Kompina and Logbajeck; in the Mamfe basin along the banks of the Manyu River; in the Rio del Rey basin around the Moko River and in the Figuil basin around Figuil. Chemical analyses have revealed a $CaCO_3$ content of 75-93% for the Mungo Valley deposits, 35-51% for Moko River, 50-92% for the Kompina, and 81-98% for Figuil. Igneous carbonate deposits (travertines) occur along the Cameroon Volcanic Line at Bongogo in Ndian Division, Etam close to Kumba and Manjo. These deposits are limited in extent and chemical analyses have shown a $CaCO_3$ content of 98% for the three deposits. Other igneous carbonates are boulders and cobbles of carbonatites that have been observed scattered over an area of about 10 hectares in Likomba close to Tiko. Metamorphic carbonates (marble) occur in Bidzar, a village along the Garoua-Maroua road with a $CaCO_3$ content of up to 95% and estimated reserves of 2.500.000tons. Those carbonates that are calcite-rich (>90% $CaCO_3$) are suitable for the manufacture of portland cement. Deposits in this category include those at Figuil and Bidzar (which are already being exploited), Kompina and the Mungo Valley. The Kompina samples are dolomitic and can be used as aglime (agricultural lime). The calcite poor deposits from Moko can also be used for liming of soils and for the treatment of acidic industrial waste. Although the travertines are calcite rich, the quantities are very limited and hence cannot serve as viable raw materials for cement production. They can however be exploited for artisanal lime production.

INTRODUCTION

Carbonate rocks have a very broad spectrum of industrial applications and are therefore important for the economic development of any country. In Cameroon, besides the deposits at Figuil and Bidzar which are mined by the Cameroon Cement Industry (CIMENCAM) for its factory, very little is known about other deposits around the country.

The occurrence of carbonate rocks in the country have been noted in the works of several authors (Gazel, 1947; Queyranne, 1951; Koch et al, 1953; Durmort, 1961; Gwoddz, 1996 and Agyingi et al, 1999; Agyingi et al, 2004). These investigations are very preliminary in nature and as such detailed information on the quality and quantity of these rocks is necessary if viable industries in this sector are to be established.

Geologic setting

Cameroon is underlain by metamorphic rocks of Precambrian age. These rocks which constitute the Basement Complex, include schists, gneisses, migmatites, amphibolites, quartzites and anatexites.

The Basement Complex rocks are associated with syntectonic old and subconcordant granites, syenites, diorites and gabbros of Precambrian age.

Other plutonic rocks within the Basement Complex include syntectonic granites and syenites of Cambrian to Ordovician age and post-tectonic granites and syenites of Jurassic-Cretaceous age (Nougier, 1980).

The sedimentary system in Cameroon is closely associated with the break-up of the large mass of Gondwanaland causing a split between Africa and South America. This separation in Aptian-Albian times (Burke et al., 1971) resulted in the formation of the Peri Atlantic basins of Cameroon namely Rio del Rey, Douala and the Kribi Campo basins; and intracontinental basins which include the Mamfe, Garoua, Maroua, Babouri Figuil, Amakossa and Mbere basins (Fig.1). There are no known occurrences of Palaeozoic rocks in Cameroon and Cretaceous sediments uncomformably overlie the Precambrian rocks in these basins.

The Cretaceous sediments in northern Cameroon comprise of a fluvio-continental series with only a few marine intercalations. Sandstones, conglomerates and mudstones predominate in the sequence, and there are local intercalations of marls and limestones.

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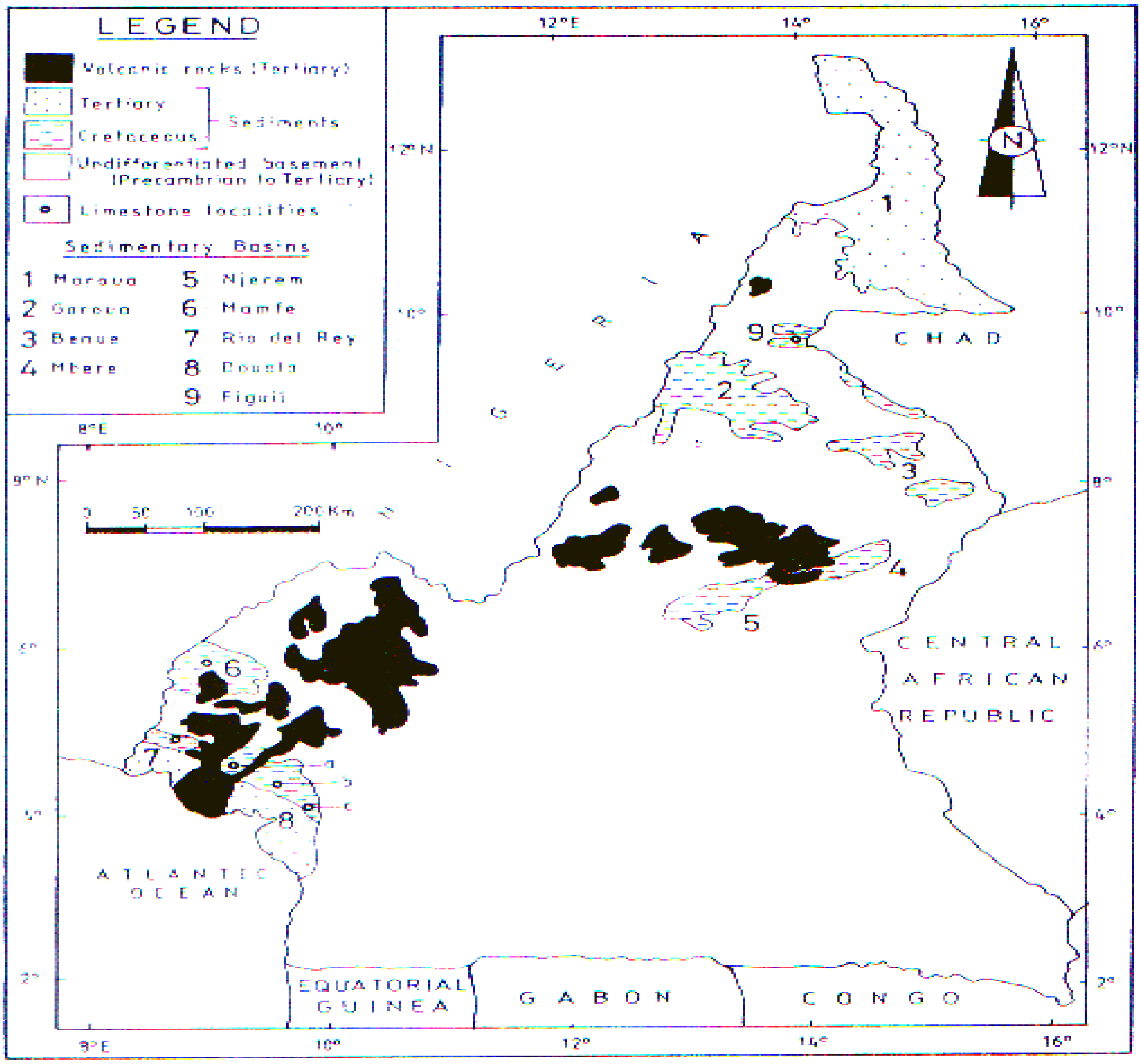

Fig. 1. Map of Cameroon showing the location of sedimentary basins which are the sites of carbonate rocks.

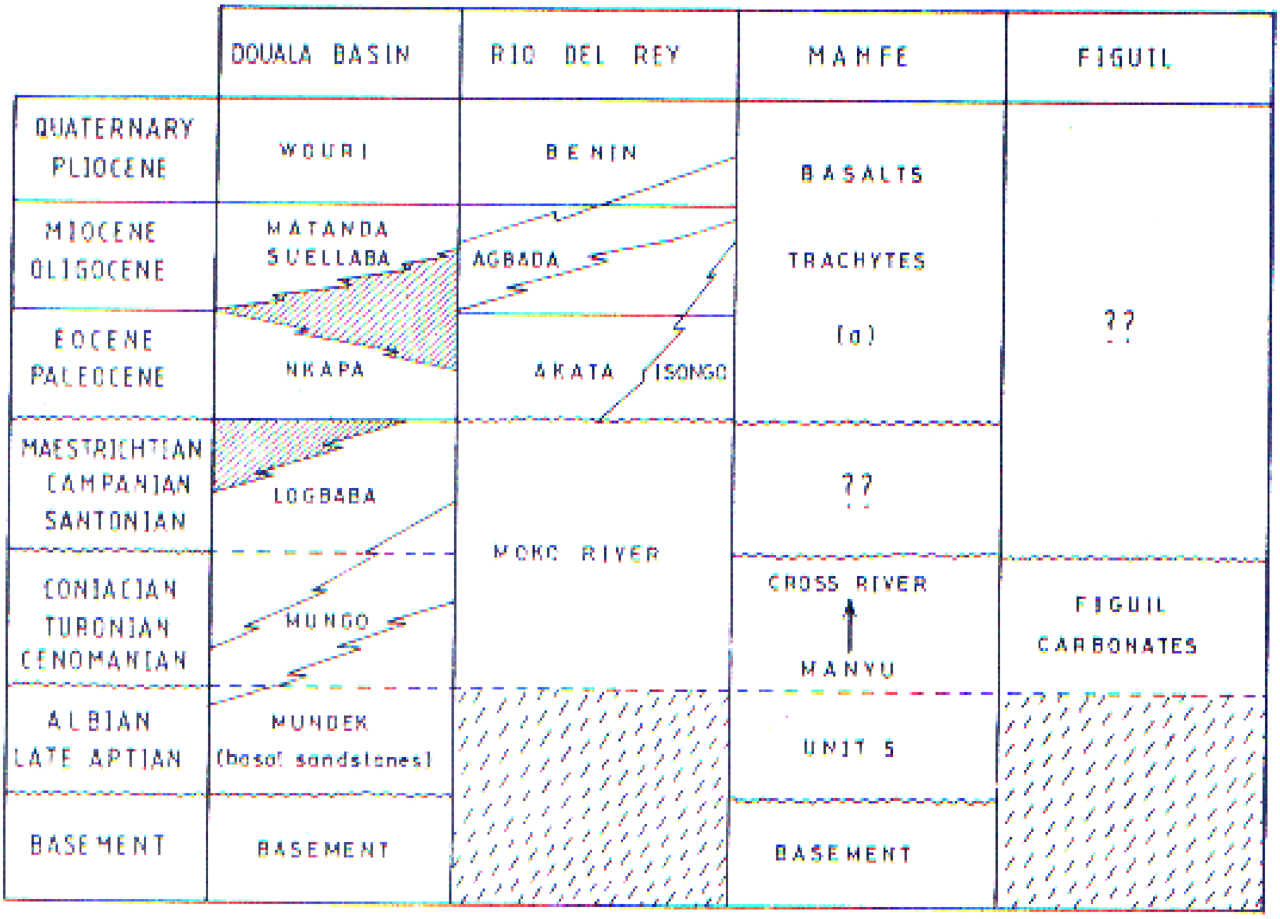

Fig. 2. Stratigraphic relationship of carbonate basins.

The Cretaceous sequence in the coastal basins commences with conglomerates and sandstones, overlain by marls and limestones that were deposited in a more marine environment. A continental facies of marls, conglomerates, shales and sandstones predominates in the Tertiary sequence. Limestones were only deposited locally. A zone of young volcanic rocks (Tertiary-Recent) traverses Cameroon (Fig.1) with a northeasterly trend (Schwartz, 1976; Paulsen et al, 1978).

METHODS

Field investigations involved the description of the geology of sample localities and collection of spot samples for subsequent laboratory analyses. The methods used in analyzing the major elements expressed as oxides include; EDTA (Ethylene Diamine Tetra-Acetic Acid) titration, ICP-AES (Induction Coupled Plasma-Atomic Emission Spectroscopy), and X-Ray Fluorescence. Other elements including Fe, Ca, Mg, Na, and K were determined by colorimetric analysis while Ba, Ni and Sc were obtained by ICP-ES. The dolomitic content was calculated using the relation in Pettijohn (1975) that 7.9% MgO is equivalent to 16.5% $MgCO_3$. The calcite content was calculated with respect to mass balance and assuming digestion of $CaCO_3$ to CaO and CO_2.

RESULTS AND DISCUSSION

Sedimentary carbonates

Carbonate rocks outcrop in 4 of the 7 major sedimentary basins of Cameroon. These include; the Douala, Rio del Rey, Mamfe and Figuil basins (Fig.1).

Table I. Chemical composition (wt%) of Mungo carbonates

Sample N^o	LOI	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	$CaCO_3$
1	41.53	3.66	1.37	0.86	52.20	0.58	93.21
2	41.10	4.11	1.14	0.68	52.09	0.36	93.02
3	34.75	14.03	3.10	1.85	42.08	0.66	75.14
4	39.46	6.54	1.91	0.71	49.09	0.66	87.66
5	38.55	7.42	2.04	1.43	48.89	0.22	87.30
6	40.82	3.52	1.27	0.86	51.39	0.36	91.77
7	39.40	6.30	2.73	1.71	48.39	0.72	86.41

Figure 2 shows the stratigraphic relationship of the carbonate basins namely Douala, Rio del Rey, Mamfe and Figuil.

Douala basin

Limestones are known to outcrop in Douala basin in three localities namely the Mungo valley, Kompina and Logbajeck (Fig 1, localities a, b, c respectively).

Mungo valley

In the Mungo valley, limestones of the Mungo Formation outcrop along the banks of the River Mungo in alternation with sandstones and shales (Fig 3). The limestones beds are 0.2 to 4 m thick and stretch from Bombe to Mbalangi over a distance of 10kms.Besides the occurrence along the Mungo River, other outcrops can be found within the vicinity of Mbalangi at two localities; namely 'Tang farm' (4^{o}30`606``N and 9$^o$26`460`` E) and London Brook (4^{o}30`795``N and 9$^o$25`849`` E). The Tang farm deposits are 0.5m thick in places and occupy an area of 5 hectares while the London Brook deposits occupy about 0.5 hectares and are 0.5m thick. The limestones of the Mungo valley are grey, very fossiferous with many bivalve shells and impressions.

Petrographic studies have shown that these limestones are predominantly biosparites (Folk, 1959). Results of chemical analysis (Agyingi et al, 1999) show that the limestones of the Mungo valley (Table 1) are calcite rich (.14 – .21% $CaCO_3$) and magnesium poor (0.22-0.72% MgO).

These limestones are poor in iron (<2% FeO) and are suitable for the manufacture of portland cement according to quality guidelines specification of Lorenz (1991). The aluminium silicate content of the Mungo River samples suggests that no further addition of clay is required for the production of portland cement

Kompina

The limestones in this area belong to the Tertiary Nkapa Formation and outcrop along the banks of the Bongue stream and range in thickness from 0.3-0.7 m (Fig 3). The limestones contain bivalve and gastropod shells. A single marlstone outcrop occurs along the Bongue stream. The exposure is up to 2 m in vertical section and 16 m in lateral extent. It is reddish brown and contains fossil shells of bivalves and gastropods. Shallow pits in the area have shown up to 60 hectares of land to be underlain with limestones with no significant overburden. Chemical analyses of these carbonates (Table 2) show a $CaCO_3$ content of 78.63 – 92.16% and $CaMg(CO_3)_2$ content of 4.48 – 11.11%, (Zisu, 2001).

Table 2. Chemical composition (wt%) of Kompina carbonates.

Sample	$CaCO_3$	$CaMg(CO_3)_2$	CaO	Mgo	Fe%
1	88.48	4.98	49.55	1.48	1.86
2	78.63	-	44.03	-	2.04
3	92.16	7.34	51.60	2.18	0.87
4	83.95	11.11	47.01	3.30	0.65
5	85.98	4.48	48.15	1.33	2.23

After (Zisu, 2001).

These carbonates can be classified as dolomitic limestones. The MgO content is generally low < 4%. The carbonates are calcite rich and can be used for the manufacture of portland cement. The limestones can also be employed in large quantities as aglime (agricultural lime). Large quantities are required in order to offset the relatively low MgO < 4% as aglime should ideally contain >6% MgO according to the BGS (1998) quality specifications.

Logbajeck

The Logbajeck carbonates are of Cretaceous age and outcrop at a plantation in Dizangue on the Douala Yaounde road. Petroleum explorers in the area (Laplaine, 1968) have described a sedimentary section 45m thick in the area consisting of limestones and marls (Fig.3).

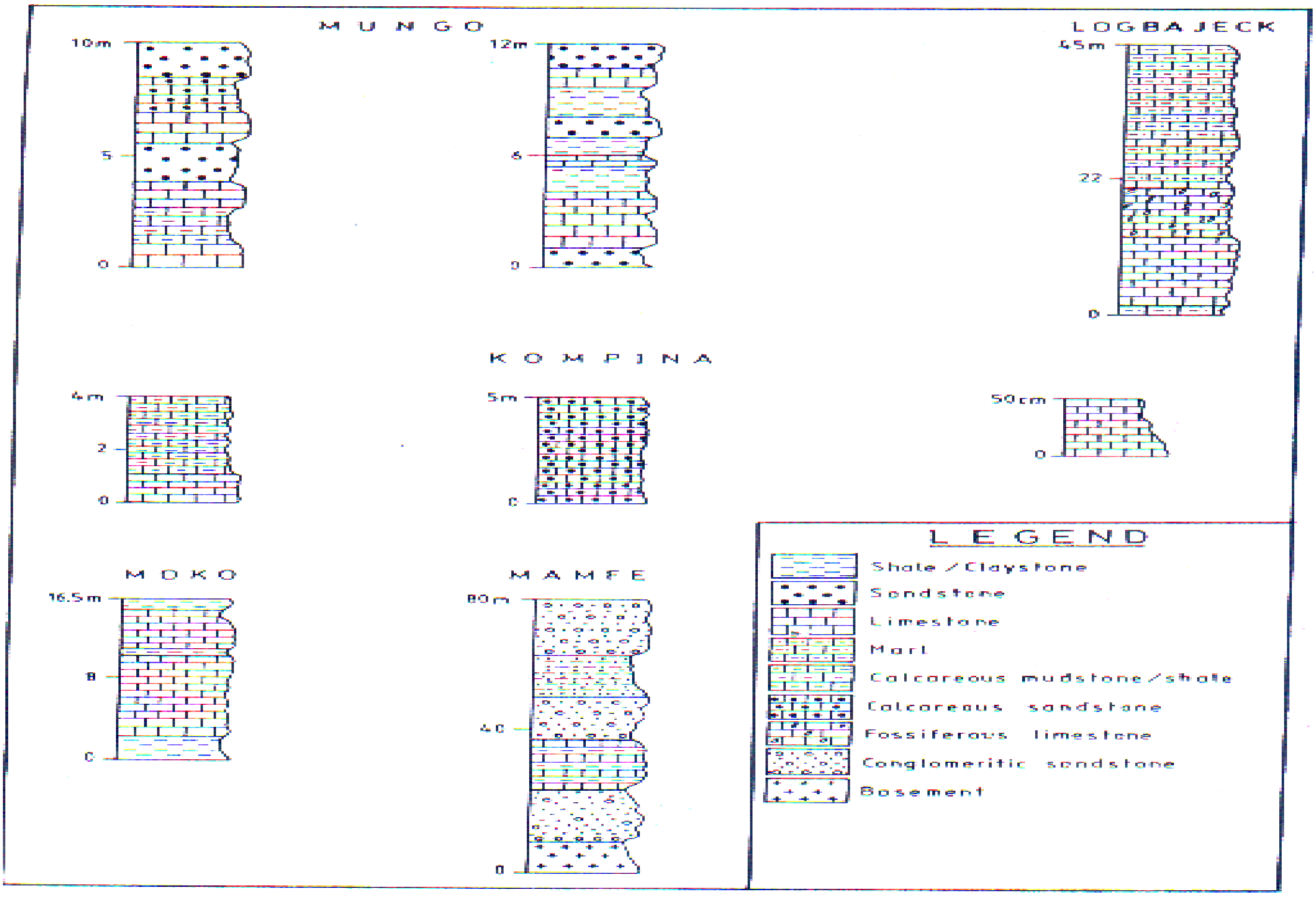

Fig. 3.Lithologic columns showing type lithology in carbonate basins.

Table 3a.Chemical composition (wt%) of Moko carbonates

Samples no	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	N_2O	K_2O	P_2O_5	TiO_2	MnO	LOI	$CaCO_3$
1	46.9	10.2	1.7	0.5	19.0	3.3	1.8	0.1	0.3	0.2	16.1	35.1
2	48.51	9.62	1.95	0.43	19.85	2.85	1.69	0.09	0.38	0.21	-	35.45

Table 3b. Elemental composition (wt%) Moko carbonates

Sample N^o	**Ca**	**Mg**	**Na**	**K**	**$CaCO_3$**
3	14.6	0.5	0.10	0.2	36.6
4	20.8	-	-	-	52.0

The limestone contain abundant bivalve and gastropod shells. No chemical analyses have been done on samples from this area and the field occurrence does not show much promise as a raw material source for cement as the deposits appear to be very minor.

Rio Del Rey basin

In the onshore Rio Del Rey basin, an alternating sequence of limestone and shale (Fig 3) has been observed in a small area (40 hectares) close to the Moko River. These deposits of the Moko River Formation are of Lower Cretaceous age. Both lithologies outcrop in vertical sequence in some gullies in the area. The shales are grey to dark grey,fossilferous and range in thickness from 1 –5 m. The limestone are grey, fossiliferous with many bivalve impressions. The limestone beds are 0.2 to 9 m thick. Petrographic analyses have shown that the limestone are biomicrites. Chemical analyses (Table 3a & b) show the limestone are calcite poor (35.1 – 52%) and are hence not considered suitable as cement-grade resources following the quality guideline specifications Lorenz (1991). They could however be used for liming soils or treatment of acidic industrial waste (Agyingi et al. 1991).

Mamfe basin

In the Mamfe basin, limestone outcrop along the banks of the Manyu River. They are intercalated with shales and sandstones (Fig 3). The exploitation of these limestone's would be extremely difficult as the banks of the river are very steep. No chemical analyses have been done on these deposits.

Figuil basin.

The deposits in the Figuil basin are located at the Garoua-Maroua junction extending towards Léré and Pala. These limestones belong to a sedimentary succession of lower Cretaceous age. Within the vicinity of Figuil, cream coloured limestones occupy an area of 600m by 40m. The reserves were initially estimated at 600.000 tons (Durmort, 1961). These deposits are presently exploited by the Cameroon Cement Company (CIMENCAM) for the manufacture of portland cement. Chemical analyses (Ongbwa 2002) show that the carbonates (Table 4) are calcite rich (81.14 – 97.95% $CaCO_3$). The reserves are fast running out and the factory has to rely on a marble deposit at Bidzar with estimated reserves of 2.500.000 tons.

Igneous carbonates

Two types of igneous carbonates have been identified in Cameroon. These include travertine deposits along the Cameroon volcanic line and carbonatite (??) boulders at Likomba in Tiko, on the south-eastern flank of Mount Cameroon.

Travertine deposits

Three travertine deposits occur along the Cameroon Volcanic Line, aligned in a SW-NE direction at Bongongo, Etam and Ngol (Fig 4). Travertines are chemogenic limestone's that precipitate from thermal mineral springs rich in $Ca(HCO_3)_2$. Such springs abound along the Cameroon volcanic line and have been shown by Tanyileke (1996) to be the very rich in HCO_3.

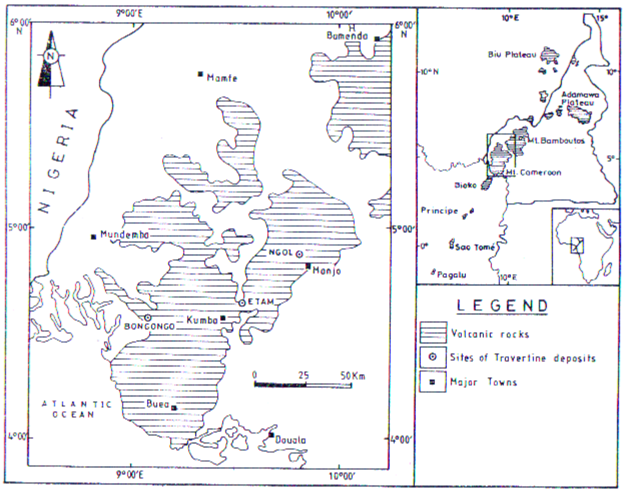

Fig. 4..Map showing sites of travertine deposits along the Cameroon volcanic line.

Bongongo deposits

At Bongongo about 2000 tons of travertines have been deposited. These deposits are very close to the Lobe hot spring, which Tanyileke (1996) found to be very rich in (HCO_3). The rocks are very compact and chemical analyses (Table 5) show that they are calcite rich (97.76% $CaCO_3$) making them very attractive as a raw material for portland cement.

However, because of the limited quantity of the deposits, they can only find use in artisanal lime burning. Initial burning trials have produced a whitish lime.

Etam deposits

The deposit at Etam is very small (about 10 tons). The travertines have been precipitated on gneisses of the Precambrian Basement Complex. The gneisses are highly fractured facilitating the occurrence of mineral springs from which the travertines are formed. These rocks are as compact as those in Bongongo and look very similar petrographically with a $CaCO_3$ content of 98.23% (Table 5). They can also find use in artisanal lime production.

Table 4. Chemical composition (wt%).of Figuil carbonates

Sample N°	Na_2O	MgO	Al_2O_3	SiO_2	SO_3	K_2O	CaO	Fe_2O_3	$CaCO_3$
1	*	1.43	0.22	0.72	0.21	0.16	54.85	*	97.95
2	*	2.03	0.09	0.17	0.20	0.04	54.42	*	97.17
3	0.19	2.97	0.07	0.35	0.16	0.03	51.84	0.05	92.57
4	*	1.57	1.63	5.13	0.23	0.12	50.85	1.44	90.80
5	0.00	1.13	1.50	4.49	0.14	0.07	50.42	1.32	90.04
6	0.23	4.52	0.12	0.32	0.17	0.03	49.24	0.26	87.93
7	*	5.08	0.84	2.56	0.16	0.04	46.62	1.19	83.25
8	*	1.66	2.59	8.06	0.13	0.08	46.56	2.81	83.14
9	0.00	7.83	0.06	0.41	0.15	0.03	45.85	0.30	81.88
10	0.06	2.38	3.55	[illegible]	[illegible]	0.40	45.44	3.90	81.14

* Beyond detection level.
After (Ongbwa, 2002).

Table 5. Chemical composition(wt%) of Igneous carbonates

Sample N°	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O5	MnO	Cr_2O_3	Ba	Ni	Sc	LOI	$CaCO_3$
LBC	.52	.22	.15	.71	53.86	.07	<.02	.06	.01	.03	<.001	497	<20	<1	43.9	97.76
LNC	.19	.06	.18	.66	54.27	<.01	<.02	<.01	.05	.11	<.001	125	<20	<1	44.0	98.27
ETM	-	-	-	-	55.00	-	-	-	-	-	-	-	-	-	-	98.23
LKM	-	-	-	-	53.76	-	-	-	-	-	-	-	-	-	-	96.00

LBC – Bongongo travertine
LNC – Ngol travertine
ETM – Etam travertine
LKM – Likomba carbonatite??
\- means not determined

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Ngol deposits

The travertines at Ngol were also precipitated on Precambrian gneisses by mineral springs. The rocks are spongy and bear a lot of plant imprints. Sometimes, they show concentric structures as a result of accretion of calcite on a plant twigs. These rocks (Table V) are calcite rich (98.27% $CaCO_3$). The deposits have been estimated at 10.000 tons and during the Second World War they were exploited at the rate of 10 tons per week (Dumort, 1961). Because of the leanness of the deposits they can also only be used in artisanal lime production. Initial burning trials have produced a greyish lime.

Carbonatites (?)

Carbonatities are an uncommon group of magmatic rocks which consist of calcium carbonate, sometimes with magnesium carbonate and very rarely strontium carbonate. They are often associated with rare-earth minerals, phosphates and vermiculite. They generally occur as a component of intrusive alkaline ring complexes in areas of ancient basement structures. Carbonatites are normally heterogeneous and may contain veins and xenoliths of other igneous rocks. However, they are often useful local sources of carbonates in areas otherwise devoid of limestones (BGS, 1993).

Boulders and cobbles have been observed strewn over an area of about 10 hectares in Likomba close to Tiko of the south-eastern flank of Mount Cameroon. The rocks are relatively soft, whitish and gray. Chemical analyses have revealed a $CaCO_3$ content of 96% (Table V). These rocks, which are relatively soft and whitish gray may be closely associated with the volcanism of Mount Cameroon and constitute the subject of further investigation. These rocks can find very good use in artisanal lime production.

Metamorphic carbonates (Marble)

Marble deposits have been described in Bidzar (Dumort, 1961) a village between Garoua and Maroua 22km to the north-east of Figuil. Outcrops of marble lenses can be found in Precambrian micaschists and quartzites. Chemical analyses have revealed a $CaCO_3$ content of up to 95% (Dumort, 1961). The most important reserve at Biou-Bidzar has been estimated at 2.500.000 tons. Here the marble is not as mixed up with the schists as in other locations making exploitation relatively easy. These deposits are presently being mined by the Cameroon Cement Company (CIMENCAM) for its factory at Figuil as the sedimentary deposits in Figuil are fast running out. The Bidzar deposits have also found use in the manufacture of floor tiles in a process which involves cutting and polishing.

CONCLUSION

Carbonate rocks that can serve as the raw material base for the manufacture of Portland cement exist in Cameroon. Besides the deposits at Figuil and Bidzar, which are presently being exploited, the deposits in the Mungo valley and Kompina are interesting enough to warrant further investigations particularly in the area of subsurface studies and reserve estimation more especially as the Figuil deposits are fast being depleted. Besides the manufacture of Portland cement, these limestones can also be used in artisanal lime production and aglime. For this purpose even the very small deposits become quite important.

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