Togo

Total population (July 2000 estimate): 5,019,000
Area: 56,785 km^2
Annual population growth rate (2000): 2.7 %
Life expectancy at birth (1998): 49.0 years
People not expected to survive to age 40 (1998): 34.2 % of total population
GDP per capita (1998): US $1,372

Togo is a small country north of the Gulf of Guinea. It extends in a north-south direction over a length of 550 km. The narrowest part of Togo is at the coastline (55 km) and the widest is in the centre (about 225 km). The coastal area consists of flat sandy beach areas and a series of lagoons and lakes. The centre of the country is mountainous and forested with deciduous trees. The northern area is gently undulating savanna country. The average annual precipitation in the north of Togo reaches 1,000 mm, in the south it is approximately 1,800 mm.

Togo's economy is based on farming and phosphate mining. The agricultural sector provides 41% of the GDP and more than 65% of the working population are involved in commercial and subsistence farming. The main food crops are yams, cassava, maize, sorghum, bananas and rice. The export of cocoa, coffee and cotton together generate about 30% of the export earnings.

Togo's mineral industry is dominated by the government-owned phosphate producer, Office Togolaise des Phosphates (OTP). Phosphate rock mining began in 1961 and exports of phosphates remain Togo's principle source of foreign earnings. Export of phosphate concentrate accounts for 20-30% of export earnings, 10-13% of government revenues and 6-10% of the GDP (Mobbs 1995). Currently Togo is the largest sedimentary phosphate rock producer in sub-Saharan Africa. Production in 1997 was 2,686,600 tonnes (British Geological Survey 1999), although the sale of phosphates to western countries has slowed down considerably, partially due to technical problems (Palut 2000), but also as a result of environmental concerns related to the relatively high cadmium content in the phosphate rock concentrate. A transfer of 40% of OTP into the private sector is planned. Also, the increase of production and the development of downstream chemical processing facilities are envisaged (Palut 2000). Apart from the export of phosphates, the mining industry is small with a local cement and construction industry.

Togo has experienced several environmental problems including coastal water pollution, deforestation and associated soil erosion problems.

Geological outline

Precambrian to early Cambrian rocks underlie most of Togo. The north-south striking Togo Belt (Dahomeyan Belt) forms a strongly deformed series of supracrustal rocks and volcanics of Neoproterozoic to early Cambrian age. The Togo Belt has been thrusted westward onto the Volta Basin, which is exposed in the northeast of the country. Cretaceous to Tertiary gently southward-dipping basin sediments occur only in the most southern part of the country.

AGROMINERALS

Phosphates

There are two types of phosphate deposits in Togo: strongly deformed Proterozoic phosphates near Bassar in northern Togo, and unmetamorphosed flat-lying Tertiary sedimentary phosphates in the south.

From an economic point of view, the most important phosphates are the phosphate-bearing Eocene beds of southern Togo. They form part of the shallow basin stretching from the southeast corner of Ghana eastward through Togo and Benin into Nigeria. In Togo, the basin sequence strikes in a northeasterly direction and dips at very shallow angles ($< 2^o$) towards the southeast.

Detailed mapping and mineral exploration of the phosphorites has identified the stratigraphic sequence and the facies distribution of the Upper Cretaceous, Paleocene and Eocene beds (Figure 2.18). Paleo-geographic reconstruction shows that the phosphates are concentrated at the margin of the basin where the thickness of the whole Eocene sequence is condensed and at a minimum (Slansky 1986, 1989; Johnson *et* *al.* 2000). A limestone barrier effectively cut off a lagoon in which the phosphates accumulated in a sedimentary trap (Figure 2.19). Postdepositional leaching (decarbonation) has caused enrichment of the Bed 1 ore zone (Van Kauwenbergh and McClellan 1990, Johnson *et al.* 2000). The phosphatic sediments are of lower - middle Eocene age (upper Ypresian - lower Lutetian) and are overlain by a continental sequence of clastic sediments (‘Terminal continental’). The whole sequence is covered by ferruginous lateritic soils. A typical lithological sequence in this area (Van Kauwenbergh and McClellan 1990), from top to bottom, is as follows:

- Top soil,
- partially indurated gravel, sand and clay of the Terminal continental (up to 22 m thick),
- Bed 0 - Eocene; wheathered phosphorite, kaolinitic, Al- and Fe- phosphates (0-2 m thick),
- Bed 1 - Eocene, pelletal phosphorite ore (francolite), currently mined (0-6 m thick),
- Bed CSC - phosphatic bedded limestone and marl. This bed is probably the lateral equivalent of bed 1,
- bicoloured clay - marker bed (0-2 m thick),
- Bed 2/3 - Eocene, marl with calcitic sand, clay beds, limestone, thin high-grade phosphorite beds (total sequence 2-8 m thick),
- Palygorskite (attapulgite) clay bed.

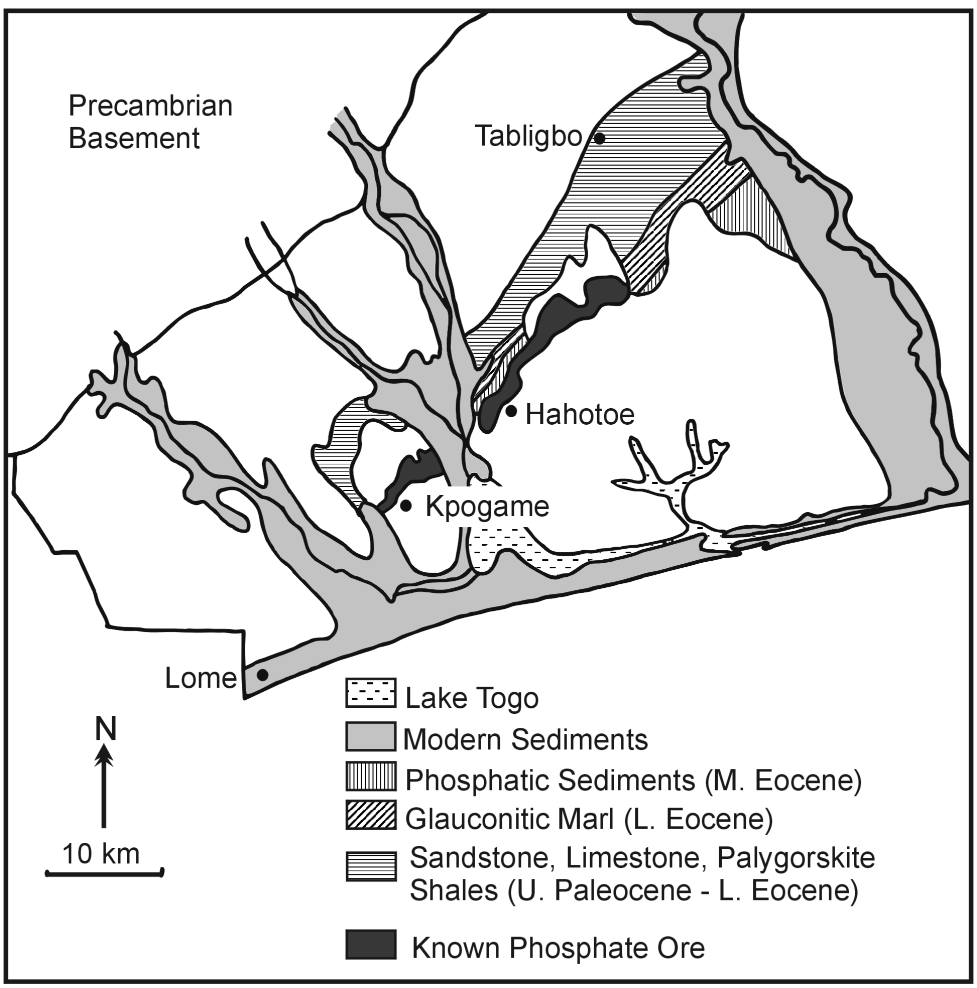

Figure 2.18: Geology of the coastal basin of Togo (adapted from Johnson *et al.* 2000).

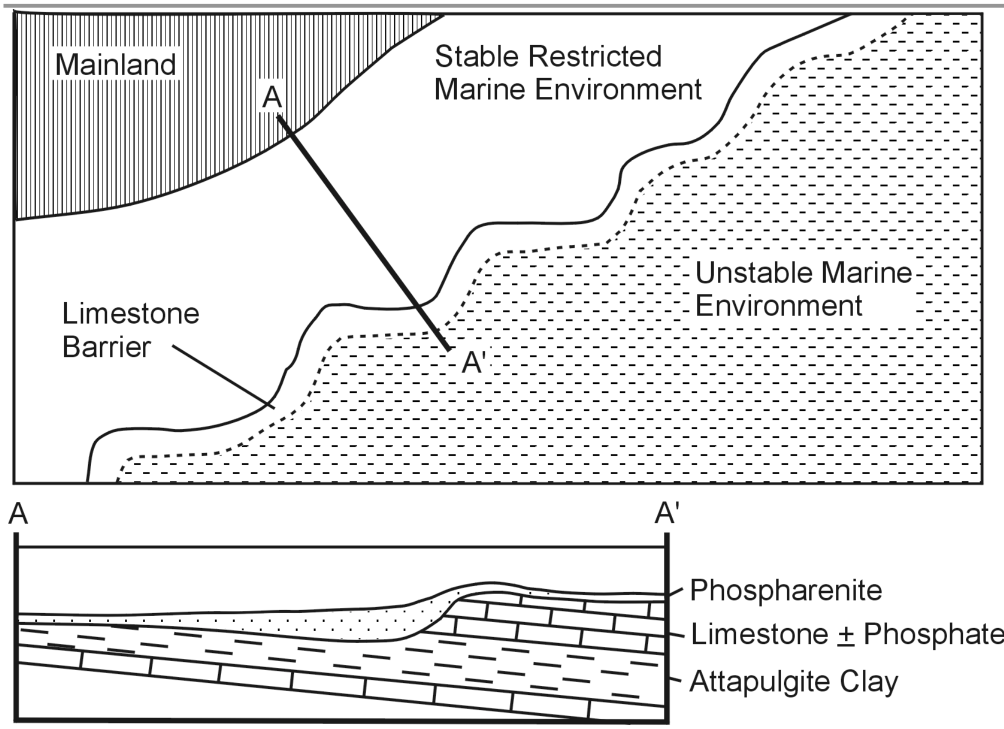

Figure 2.19: Depositional trap of the Togo phosphate ore (adapted from Slansky 1986).

The phosphate rock deposit that is currently mined is confined to the zone between the 'calcareous barrier' and the margin of the basin.

The size of the phosphate deposit is 30 km long; the width varies from a few hundred metres to 2 km. The unconsolidated ore body varies in thickness from 2-6 m and is overlain by 7-30 m of sands and clays. When the extraction of the Togo phosphate deposit began in 1961 the identified reserves of marketable concentrate were estimated at 130 million tonnes.

A typical concentrate of Togo phosphate rock (Togo PR) has a P_2O_5 concentration of 36 to 37% and is low in Al_2O_3 (1%) and Fe_2O_3 (1.5%). Mineralogical and chemical studies show that the mined and concentrated phosphate mineral is a low-substituted unreactive apatite. Van Kauwenbergh and McClellan (1990) carried out detailed mineralogical studies from drill cores from the mining area. They report variations in the crystallographic and chemical properties of the francolites. The crystallographic unit-cell a-values of the Togo francolites vary from bed 1 (9.348 Å) to 9.326 Å and 9.324 Å in Bed 2/3 of the deposit. The average unit-cell a-value of the concentrate, according to Van Kauwenbergh and McClellan (1990), is 9.349 Å. The refractive index of the francolites varies from 1.618 in Bed 1 to 1.608 in Bed 2/3. Mokwunye (1995) reports an a-value of 9.354 Å, and a molar PO_4/CO_3 ratio of 12.3 of the concentrate. These mineralogical data together with solubility data from Kpomblekou *et al.* (1991) (citrate solubility = 1.7% P_2O_5) and Abekoe and Tiessen (1998) (neutral ammonium citrate solubility = 1.3% P_2O_5) illustrate the low reactivity of the Togo PR.

The specific surface area of Togo PR is low: 7.1 m^2/g in the 0.5 mm fraction and 9.9 m^2/g in the 0.1 mm fraction. In comparison, the reactive Tilemsi PR from Mali has a surface area of 26.4 m^2/g in the 0.5 mm fraction and 34.2 m^2/g in the 0.1 mm fraction respectively (Truong and Fayard 1995).

A chemical drawback of the Togo PR is its relatively high cadmium content (Cd mean = 58 mg/kg, range 48-67 mg/kg). The Cd concentrations are greater than that permitted for use in Western Europe, and this has some obvious influence on sales.

Currently, the ore is excavated by large bucket/wheel excavators in quarries, one progressing south-westward from Kpogame, the other northeastward from Hahotoe. A railway transports the ore to Kpeme, approximately 30 km from the mines. Here, the ore is scrubbed, screened, and hydrocylconed to remove clays. The product is a concentrate with P_2O_5 contents of 36-37%. The plant capacity is 3.5 million tonnes per year.

There is no facility for downstream processing of Togo PR into phosphate fertilizer. In the 1990s most of the concentrate was exported to Canada, the Far East and South Africa. In recent years, an agreement was negotiated with Indian Ocean Fertilizers to establish downstream processing (Bowyer 1996).

In 1997, the Office Togolaise des Phosphates (OTP) produced 2,686,600 tonnes of Togo PR (concentrate) for export, the corresponding export figures for 1996 and 1995 are 2,685,500 and 2,652,100 tonnes respectively (British Geological Survey 1999). In recent years exports of Togo phosphates have declined, especially after the cancellation of a large export contract to Canada. Large tonnages of Togo PR concentrate are currently shipped to South Africa where they are blended with phosphates from Phalaborwa and processed before being shipped to India.

The physical processing (beneficiation) of the Togo phosphate ore in Togo results in the recovery of 1 metric tonne of phosphate concentrate per 2 tonnes of raw ore. Up to 500,000 tonnes of phosphate fines are discarded annually into the Gulf of Guinea (Gulf of Benin), which, environmentally speaking, is a cause for concern.

Gnandi and Tobschall (1998) analyzed the concentration and distribution of major and trace elements in coastal sediments near the dumping site of the phosphate fines. They showed high concentrations of Cd, Cr, Pb, Zn, Cu and Ni in the coastal sediments near the dumping site. The highest Cd enrichment factor of 100 was measured in relatively coarse sediments, close to the dumping site and along the shore, transported by longshore currents. Gnandi and Tobschall (1998) also point out that Cd is easily mobilized in seawater and thus pollutes much larger areas of the Gulf of Guinea (Gulf of Benin).

Agronomic Testing of Togo Phosphate Rock

Many agronomic tests have been carried out with Togo PR. Studies by Nnadi and Haque (1988), Uyovbisere and Lombim (1991), Kato *et al.* (1995), and Abekoe and Tiessen (1998) confirm that the unmodified, mineralogically 'unreactive' Togo PR is largely ineffective on tropical P-deficient soils. Only one study, on acid soils of southeastern Nigeria (Maduakor 1994), showed slightly more promising results for directly applied Togo PR, especially in the second year of cropping.

It seems evident that Togo PR with its low solubility requires modification to become more agronomically effective. Agronomic experiments with partially acidulated and compacted Togo PR show encouraging potentials (Bationo *et al.*1986; Kato *et al.* 1995). Togo PR was applied in the unacidulated and partially acidulated form on alfisols in northern Nigeria and Togo, as well as on ultisols in Sierra Leone (Bationo *et al.* 1986). The agronomic data show that the unacidulated directly applied Togo PR was ineffective on all sites due to its low reactivity. However, as partially acidualted PR (PAPR - 50% H_2SO_4) it proved 72% as effective as SSP in Nigeria, 82% in northern Togo and 103% in Sierra Leone (Bationo *et al.* 1986).

The evaluation of the effectiveness of natural and partially acidulated acidulated PR using P-32 isoptopic dilution techniques (Kato *et al.*1995) showed that Togo PR in a blended (50% Togo PR, 50% TSP) and compacted form as well as partially acidulated (PAPR) had a relative agronomic effectiveness in comparison to SSP of over 72% and 84% respectively for dry matter yield of maize.

Other phosphates

Apart from the flat-lying relatively unconsolidated Eocene sedimentary phosphates in the south of the country there are compact and folded Neopropterozoic phosphorites reported from north-central Togo (Castaing 1989). The Neoproterozoic phosphates in the Bassar area are of comparable age to the phosphates in Benin, Burkina Faso and Niger (Castaing 1989). The phosphate beds, up to 1 m thick, have been explored by means of geological mapping and drilling. North of Bassar these folded beds are more than 7 km long. East of Bassar they can be traced over a distance of 6 km, and south of Bassar over a distance of 7 km. No specific details on grade, volume and mineralogical and chemical composition of the phosphate beds are available.

Limestone/dolomite

There are large deposits of dolomitic marbles, dolomitic limestones and limestones in Togo. Dolomite marbles are economically exploited by Société Togolaise de Marbrerie et Matériaux (SOTOMA) at Gnaoulou, 30 km south-southwest of Atakpame. Reserves are estimated at 20 million tonnes. The deposit is used for the production of ornamental marble, and to a lesser degree, calcined lime. Whether any of the fines or the dolomitic lime are used for agricultural purposes is not known. Another 19 occurrences of dolomitic marbles, many of them of smaller extent, have been reported by Lorenz (1996).

Dolomitic marbles and limestones are known from the Voltaian. The dolomitic marbles at Pagala in central Togo have been worked by SOTOMA since 1984 for building and ornamental purposes. Lorenz (1996) noted that lime could be produced from the wastes produced during the extraction of the blocks. The dolomitic ‘wastes’ account for approximately 30% of the production of the blocks. This material has a favourable composition (CaO = 29%, MgO = 20%) for use as agricultural dolomitic limestone.

Very extensive limestone resources also occur in the coastal basin of Togo. Extensive Paleocene limestones occur between Sika Kondji, Tokpli and Tabligbo. The deposit at Tabligbo (Fig. 2.18) provides the cement industry of Togo with limestone raw material. Annual production capacity of this plant is 1.2 million tonnes.

It is noteworthy that the 100 million tonnes of limestones at Aveta (18 km northeast of Lome) cannot be used as raw material for the cement industry because of elevated phosphorus concentrations (Lorenz 1996).

Glauconite

Glauconitic sands are commonly associated with the Togo phosphate beds. However, no details of grade and volume are available.

Rock wastes

As described earlier, a total of 500,000 tonnes of phosphate fines resulting from phosphate beneficiation are currently discarded into the Gulf of Benin each year, creating serious environmental problems along the coast.

Other mine ‘wastes’ include the dolomite fines produced during the production of ornamental stone and marble.

Agromineral potential

Togo's potential to provide agrominerals for agricultural production is high. Most of the existing phosphate resources of Togo are currently exported in the form of phosphate concentrate (Togo PR). Local modification techniques of Togo PR concentrate and phosphate fines, for instance phospho-composting, partial acidulation, blending with N-fertilizers and compacting or pelletizing with other nutrient compounds, should be explored.

Efforts should be made to substantially reduce the disposal of phosphatic material into the ocean, and develop low-cost phosphatic soil amendments from these 'waste' materials.

In addition, there are many dolomite and dolomitic limestone occurrences in the country, which could be used on a small-scale if soil conditions require liming materials and/or Mg additions.

'Wastes' from the marble and ornamental stone industry may be suitable for the use as agricultural limestone.

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