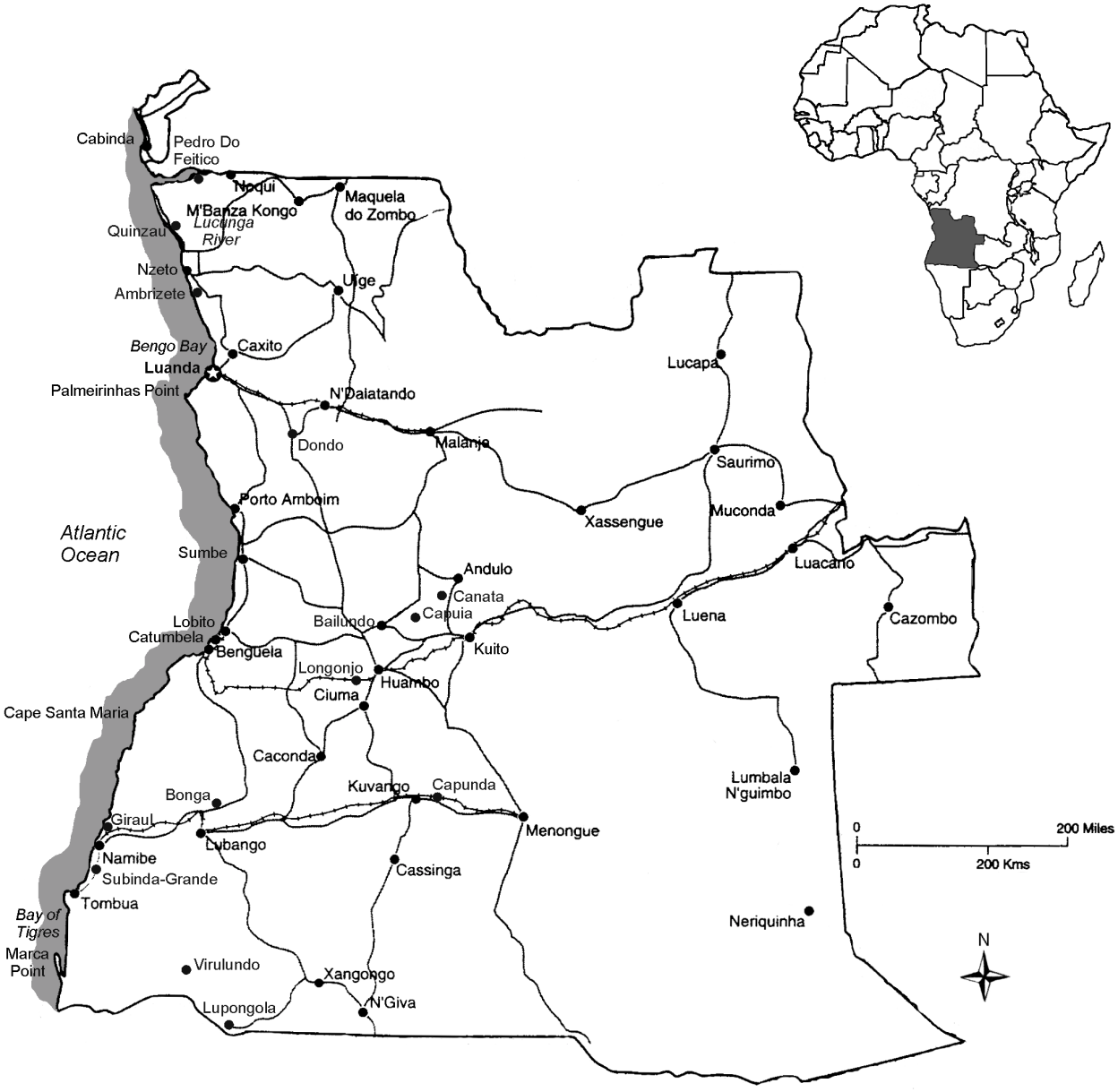
Angola

Total population (July 2000 estimate): 10,145,000
Area: *1,246,700 km^2
Annual population growth rate (2000): 2.15%
Life expectancy at birth (1998): 47.0 years
People not expected to survive to age 40 (1998): 37.7% of total population
GDP per capita (1998): US $1,821



* includes the Cabinda enclave, located between the Republic of Congo and the Democratic Republic of Congo.

Angola, the second largest country in sub-Saharan Africa, consists of various landscapes, from a coastal lowland, 20-30 km wide in the south and 100 km wide in the north, to a dissected tableland at altitudes around 1,500-2,000 m that slopes gently eastward towards the Congo and Zambezi Basins.

Angola's agriculture is mainly based on subsistence farming with about 75% of the Angolan population dependent on agricultural production. At present, only 3% of the total land area is under cultivation. In 1999, the agricultural sector accounted for 12% of the GDP. Major food crops are cassava, maize, bananas, sweet potatoes, millet, rice, sugar cane and beans. The main export crop is coffee.

Angola is a country well endowed with mineral and energy resources. This industry is currently dominated by the production of oil and diamonds. The enclave of Cabinda to the north of the country is the source of approximately 70% of Angola's total oil production. Angola is the second-largest oil producer in sub-Saharan Africa (after Nigeria) and has significant reserves of natural gas (1.6 trillion cubic feet). Some 85% of this natural gas is currently burned off (flared) due to lack of infrastructure.

Much of Angola's large mineral resource potential remains undeveloped due to a long-lasting civil war that has displaced about one million Angolans.

Geological outline

The geology of Angola is dominated by Proterozoic rocks. Neoproterozoic rocks of the Bembe Group occur in the western part of the country. The 'Schisto-Calcaire,' which is part of the Neoproterozoic West Congolian Supergroup that outcrops mainly in the northwest of the country. The lower part of the 'Schisto-Calcaire' is made up of stromatolitic and oolitic limestones and rests on tillites. In the coastal basin, a 4,000 m thick sequence of Cretaceous to Tertiary and Quaternary sediments rests unconformably on the Precambrian. Kalahari sands cover the eastern part of the country.

AGROMINERALS

Phosphates

There are several distinct phosphate regions in Angola, most of them in the coastal region (Figure 2.1). The phosphates are grouped into at least four clusters:

1. the Cabinda phosphates (9 known deposits),
2. the Lucunga River phosphates (3 major deposits),
3. the Luanda phosphate (1 occurrence),
4. phosphates associated with carbonatite complexes (reported in 6 of 11 known carbonatite complexes).

1. The Cabinda phosphates.

Extensive sedimentary phosphate deposits are located in the central part of the Cabinda District in areas of relatively low-lying terrain. The phosphate beds, Upper Cretaceous (Maastrichtian) to Lower Eocene in age, are concentrated in two zones. The lower phosphate zone has three beds, 3 m, 12 m and 9 m thick, and the upper phosphate zone has bed thickness ranging from 13-23 m. The phosphatic beds are made up of pellets, oolites and organic fragments (fish teeth, scales and bones). The P_2O_5 content of the lower beds is 10-20% and the grade of the upper beds is 15-20% P_2O_5. Weathering and leaching extend to depths of 100 m or more and in some places have increased the grade of the phosphate beds to 32-38% P_2O_5 (Hodge and Partners 1978).

The phosphate-bearing beds are faulted and mildly folded into northwest striking broad anticlines and synclines, which continue across the border into the neighbouring Democratic Republic of Congo (Figure 2.2).

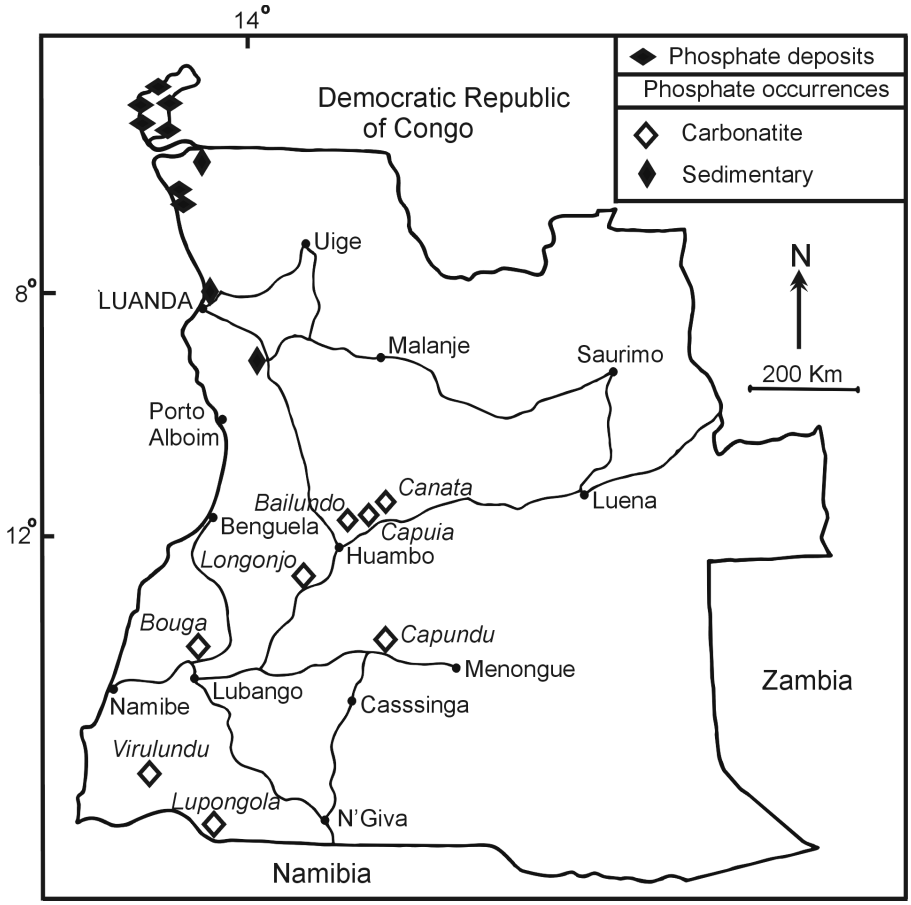


Figure 2.1: Location of phosphate resources of Angola (after Hodge and Partners 1978).

Prospecting in the Cabinda enclave was initially carried out during the late 1960s and early 1970s by Companhia de Fosfatos de Angola (COFAN). It included rotary drilling (201 boreholes, total length = 19,232 m), core drilling (29 holes, length = 626 m), sinking of 9 shafts (total depth = 131 m), as well as gamma-ray and resistivity logging, microscopic studies and chemical analyses. The data obtained were re-evaluated by, among others, Hodge and Partners (1978) and Terraconsult (1983).

Terraconsult (1983) described several phosphate outcrops of the Cabinda District (Figure 2.2) in detail:

- At Mongo Tando (10 km northeast of Landana, along the Itombe Creek): the 3-4 m thick phosphorite layer contains 17-30% P_2O_5.
- At Chibuete, along Lake Massabi, layers contain 15-26% P_2O_5 over a strike length of 6 km.
- At Cacata (some 30 km east of Landana, along the Nhenha Creek): a lenticular phosphorite sequence, up to 14 m thick, contains up to 35% P_2O_5.
- Near Cambota (10 km east of Dinge, at the left bank of the Sanzo River): phosphorite beds contain 12-26% P_2O_5.
- At Chivovo (10 km north of Dinge, at the Tuma Creek): lenticular phosphatic sandstones contain 29% P_2O_5.

Reserve estimates of the phosphates in the Cabinda District differ considerably. Notholt *et al.* (1989) estimated that five groups of deposits in Cabinda contain 16 million tonnes of phosphates, of which 3.3

million tonnes are in the proven category. This is in contrast to the results of the Phase I results of COFAN, which indicated 110 million tonnes of high grade recoverable phosphate concentrates at 34-38% P_2O_5 and a further 50 million tonnes of concentrates containing 32-34% P_2O_5.

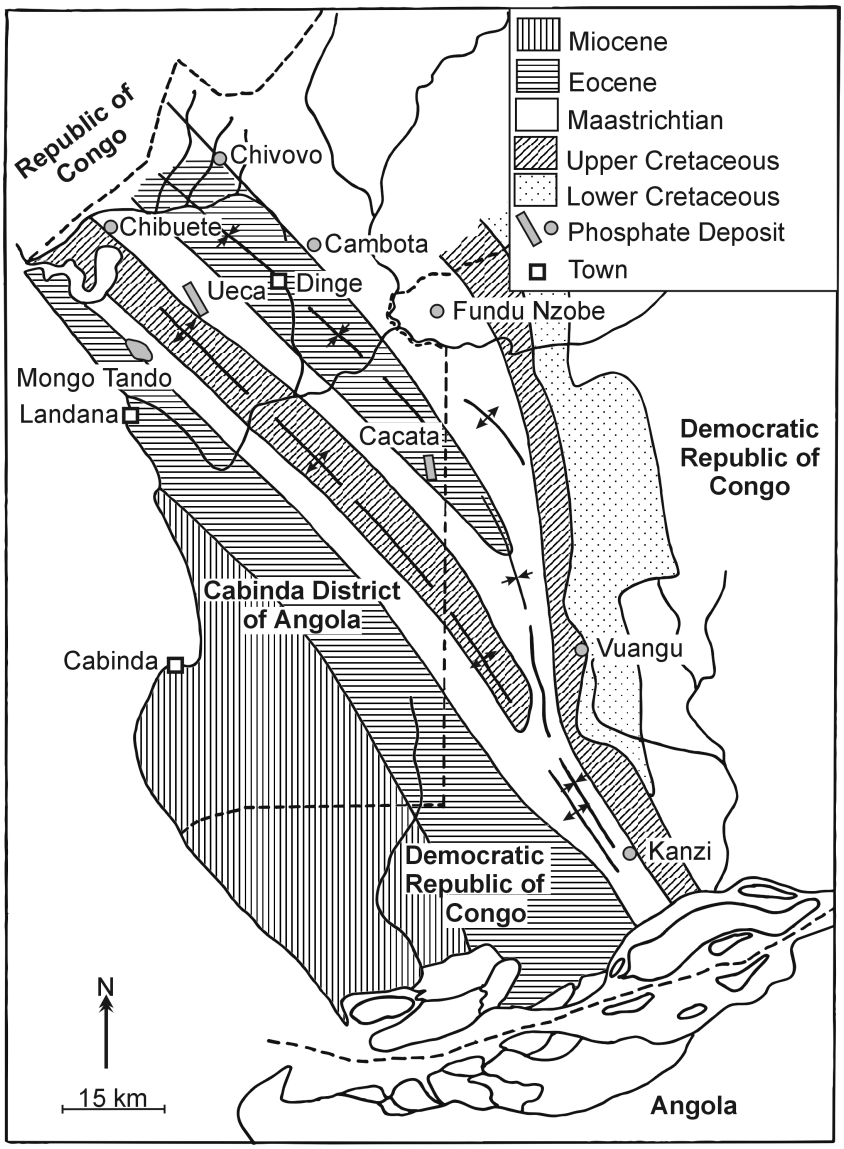


Figure 2.2: Location of phosphate occurrences and deposits in Cabinda District, Angola, and the Bas Congo area, Democratic Republic of Congo.

Hodge and Partners (1978) re-visited the COFAN Phase I and Phase II investigations (412 rotary boreholes, 40 cored boreholes). These findings confirmed probable reserves of 21 million tonnes ranging from 2.1-16.5% P_2O_5 (weighted average 10.1% P_2O_5) within a one square kilometer central section of the Mongo Matonde area of Cabinda District. The thickness of the phosphate beds range from 6.6-18.2 m with a waste-to-ore ratio ranging from 0.0:1-4.5:1. Chemical results from outcropping rock sequences confirm the high phosphate grades. For instance, Hodge and Partners (1978) provide chemical analyses of the original ore (not beneficiated) from the uppermost bed (3 m thick) of the upper phosphate zone in an old quarry at Mango Tando. The composition of the phosphates is: 37.50% P_2O_5, 51.57% CaO, 0.94% Fe_2O_3, 1.62% SiO_2 and 3.84% F. Analyses of the reactivity of a 37% P_2O_5 concentrate from Cabinda showed a neutral ammonium citrate (NAC) solubility of 4.5%, indicating high solubility (McClellan and Notholt 1986).

The evaluation of the exploration work indicated that the previous work had some shortcomings, especially with regard to core recovery. Hodge and Partners (1978) indicated that the resource estimates may be too high.

The high-grade near-surface phosphate beds with a high reactivity could be easily extracted and processed by small-scale methods for local consumption. Based on the relatively high solubility of the phosphate rocks, the agronomic effectiveness is expected to be high in phosphorus-deficient acid soils. So far, no data are available on their agronomic effectiveness in Angolan soils.

2. The Lucunga River phosphates

The second largest potential for Tertiary phosphate development exists in the Lucunga River area east of Quinzau, approximately 40 km north of the port city of Ambrizete. The phosphate beds are of the unconsolidated nodular type. The deposits of Coluge and Lendiacolo are middle-upper Eocene in age and the reworked phosphate deposit of Quindonacaxa is of Pleistocene age (Hodge and Partners 1978; El-Kadi 1980). Antonio Martins (1963) started to investigate the Quindonacaxa deposit in detail in the early 1960s. A Bulgarian team (Bulgargeomine) and Geomina studied the deposit in 1979 using both geological and geophysical methods. The phosphate reserves at Quindonacaxa alone, based on data of Antonio Martins (1963), are 20,255,903 tonnes at 18.54% P_2O_5. Agronomic work by Melo (1984) indicated good agronomic effectiveness of Quindonacaxa PR applied directly on acid soils (pH< 5.5). The study concluded that 2.5 times more P in the form of PR are required to obtain the same yield results as with superphosphate.

A small phosphate resource in a selected area, 0.5 km^2 in size, within the Qindonacaxa zone was proposed for phosphate extraction. The reserves in this small area were calculated to be 199,652 tonnes of concentrate at 30.96% P_2O_5 (El-Kadi 1980), sufficient to run a pilot plant for about 6 years at an annual production rate of 30,000 tonnes, or about 12 years at 15,000 tonnes. This part of the deposit has been mined and operated intermittently between 1981 and 1984 by the state owned company Fosfatos de Angola (FOSFANG) under a joint venture with Bulgaria (Premoli 1994).

Total resources in the three main deposits of the Lucunga valley have been estimated at some 28 million tonnes of phosphate rock with 18-26% P_2O_5. The phosphate beds are commonly 0.2-2.0 m thick with localized areas having a thickness of over 5 m. Overburden varies from 0.1 m in the Lendiacola area to 2.4 m in the Quindonacaxa area.

3. Other sedimentary phosphate occurrences

Sedimentary phosphates of various grades and volumes are reported from Pedra do Feitico close to the Zaire River at the border to the Democratic Republic of Congo, and small occurrences south of the Lucunga phosphate zone.

Calcareous phosphorites of unknown quality and quantity are found near Sassalemba, 40 km northeast of Luanda, and at Lunga Riamica, 15 km south of Dondo (Terraconsult 1983). McClellan and Notholt (1986) describe a very low grade (5% P_2O_5) phosphate occurrence at Subinda, south of Namibe (previously called Mocamedes).

4. Phosphates associated with carbonatites.

Igneous phosphates are known from several Cretaceous carbonatite complexes in Angola. Details on these carbonatite complexes that occur along a northeast-southwest striking structural line (passing west of Huambo) have been published by De Sousa Machado (1958, quoted in Heinrich 1980), Gittins (1966), Issa Filho *et al.* (1991), and Alberti *et al.* (1999). Following this line from northeast to southwest, the main phosphate-bearing carbonatites are: Canata, Capuia, Bailundo, Longonjo, and Bonga (Figure 2.1). South of this line, but following the same structural trend, are the phosphate-containing Capunda, Lupongola and Virulundo carbonatites.

The apatite-bearing Canata carbonatite, 10 km southwest of Andulo, contains in its centre titaniferous magnetite and strongly radioactive minerals. This is a mineral association often found together with apatite enrichments in carbonatites. The Bailundo carbonatite contains phoscorites (apatite-forsterite-magnetite) with apatite cumulates reaching up to 39% P_2O_5 (Alberti *et al.* 1999). The Longonjo carbonatite complex, 4 km southwest of Longonjo (Figure 2.1) contains abundant apatite, barite and magnetite (Premoli 1994). In grab samples collected from the Bonga carbonatite, which contains approximately 800 million tonnes of Niobium ore at 0.5% Nb_2O_5, the phosphate content reached up to 10% P_2O_5 (Terraconsult 1983). Other carbonatite complexes with known phosphate occurrences are Virulundo, Lupongola, and Capunda (Terraconsult 1983; Alberti *et al.* 1999). According to Issa Filho *et al.* (1991), the Bailundo and Bonga carbonatites contain the highest concentration of phosphates in the unweathered rocks.

Most of the surveys were carried out in the primary (unweathered) carbonatite environment. No data are available on enrichments in the weathered residual soil environment of the carbonatites, which in other countries provide the largest and most easily extractable phosphate resources.

Limestone/dolomite

Coastal sediments form the best resources for extracting limestones, but also carbonatites and Neoproterozoic 'Schisto-Calcaire' metasediment with stromatolitic and oolitic limestones and dolomitic limestones have good potential.

Sedimentary limestones for the production of cement is abundant in the coastal zone. The carbonatites in various parts of the country may provide good resources for liming material, but no thorough assessment has been made.

A different source of carbonate that could be used for agricultural purposes is the waste from marble quarrying. These wastes can amount to 30% of total production and in 1994, Angola produced 244,000 m^3 marble in the southwest of the country (Kronsten 1994).

Gypsum/anhydrite/sulphur

Gypsum/anhydrite is known from the Cretaceous coastal basins of Angola, with small occurrences of anhydrite reported from the lower Cretaceous Cuanza Basin. Gypsum occurrences are reported from near Cabo Ledo (80 km north of Luanda), and Dombe Grande, 50 km south of Benguela. In the Dombe Grande area, the gypsum deposit ('Dombe Grande Gypsum') of lower Cretaceous (Aptian) age is up to 50 m thick (Duarte Morais and Sgrosso 2000). In both the Cabo Ledo and Dombe Grande gypsum deposits, there are also fine layers and 'small pockets' of elemental sulphur (Terraconsult 1983).

Angola produced approximately 20,000 tonnes of gypsum per year in the 1980s.

Glauconite

A ‘considerable glauconite deposit’ is known from Giraul, close to the port city of Namibe (previously called Mocamedes) (Terraconsult 1983). However, no detailed information on the deposit, including thickness and overburden, is provided.

Agromineral potential

The agromineral potential of Angola is good. The development of Angola’s agromineral resources depends on soil needs, on market demands, and on infrastructural and political stability factors. From the resource side it is evident that widespread sedimentary phosphorites with high grades occur close to the surface in the Cabinda District and in the Lucunga River area. Other phosphates along the coastal zone have been discovered but not studied in detail, for example, the phosphates of Sassalemba. The few reliable data on chemistry and mineralogy of the sedimentary phosphates of Angola indicate that the phosphorites described as bone fragments, pellets and oolites are largely francolites with a high agronomic potential, especially in acid P-deficient soils. Initial pot trials with Quindonacaxa PR indicate potentially good agronomic effectiveness on acid soils.

Additional attention should be given to possible phosphate mineralizations in the Neoproterozoic of the West Congolian Supergroup. Chakravarty (1982) indicated positive tests on phosphates from a stromatolitic specimen from southern Angola.

Apart from the sedimentary phosphates, there are phosphate-enriched carbonatites in Angola, especially Bonga and Bailundo. The core of the Bailundo carbonatite reportedly contains apatite cumulates. A good potential exists to delineate phosphate enrichments in residual soils over these and other carbonatites.

The potential of developing limestone/dolomite deposits from coastal sediments, dolomitic metasediments and from carbonatites is considered good.

The gypsum deposits of the Dombe Grande area should be investigated for their potential to reduce Al-toxicities in acid soils, and for the amelioration of sodium-affected soils.

The potential of using glauconite for local perennial crop or tree crop production in coastal areas needs to be tested.

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