

April 8, 2024

## News and notes

Before going on to discuss the geology and geopolitics of Côte d'Ivoire, here are some news items I thought were interesting.

## Geopolitics

- France and its former African colonies: [The Sahel's 'Axis of Resistance'](#).
- [A great wealth transfer is underway: How the West lost control of the gold market](#); “Gold is the money of kings, silver is the money of gentlemen, barter is the money of peasants – but debt is the money of slaves.” [Norm Franz](#).

## Research

- This debate ain't over yet: [The Anthropocene epoch that isn't – what the decision not to label a new geological epoch means for Earth's future](#).
- Geological history: [A proposed chronostratigraphic Archean–Proterozoic boundary: Insights from the Australian stratigraphic record](#).
- More geological history: [Zircon U–Pb ages of granitic and mafic dikes associated with granitoids and metamorphic rocks of the Ryoke Belt in the eastern Kii Peninsula, southwest Japan](#).
- [Paleoproterozoic Rocks of the Belcher Islands, Nunavut: A Review of Their Remarkable Geology and Relevance to Inuit-led Conservation Efforts](#); sorry, behind a paywall – [join the GAC!](#)
- [Testing the salinity of Cambrian to Silurian epicratonic seas](#).
- Petrology: [Magmatic, Metamorphic and Structural History of the Variscan Lizard Ophiolite and Metamorphic Sole, Cornwall, UK](#).
- Fun, fun, fun – with molten rock: [Playing with molten lava in Iceland](#).

## Plate Tectonics

- [Detrital isotopic record of a retreating accretionary orogen: An example from the Patagonian Andes](#); Phys.org summary [here](#).
- [A review of the Caledonian Wilson cycle from a North Atlantic perspective](#).
- New volume of research from the Lyell Collection of The Geological Society: [Characterization, Prediction and Modelling of Crustal Present-Day In-Situ Stresses](#).
- [Segmentation of the Tashkurgan normal fault in the eastern Pamir: Insights from geomorphology and thermochronology and implications for fault-slip transfer](#).

- [Neogene-Recent Reactivation of Pre-Existing Faults in South-Central Vietnam, With Implications for the Extrusion of Indochina.](#)
- [Mega-Folding of a Basement During Incipient Intra-Plate Continental Subduction \(Alpine Central Iberia\).](#)

## Paleontology

- [Fossils document evolutionary changes of jaw joint to mammalian middle ear](#); related: [Jurassic shuotheriids show earliest dental diversification of mammaliaforms.](#)
- Early terrestrial vertebrates: [The axial skeleton of \*Tiktaalik roseae\*](#); Phys.org summary [here](#).
- Live fast and die young: [Osteohistological insight into the growth dynamics of early dinosaurs and their contemporaries](#); Phys.org summary [here](#).
- [Pliosaur sea monster enters world record books.](#)
- Evolution: [Heat flows enrich prebiotic building blocks and enhance their reactivity](#); New Scientist summary [here](#).
- More evolution: [Global latitudinal gradients and the evolution of body size in dinosaurs and mammals](#); Phys.org summary [here](#).

## Mining and Energy

- Related to today's post: [Ivanhoe Electric earns into 60% of nickel-copper project in Côte d'Ivoire.](#)
- Ore body geology: [Trace Element and Sulfur Isotope Signatures of Volcanogenic Massive Sulfide \(VMS\) Mineralization: A Case Study from the Sunnhordland Area in SW Norway.](#)
- More ore body geology: [Magmatic evolution of the Kolumbo submarine volcano and its implication to seafloor massive sulfide formation.](#)
- AI and mineral exploration: [Leveraging Domain Expertise in Machine Learning for Critical Metal Prospecting in the Oslo Rift: A Case Study for Fe-Ti-P-Rare Earth Element Mineralization.](#)
- Free book (PDF download): Kesler, Stephen E.; Simon, Adam C., 2015, [Mineral Resources, Economics and the Environment.](#)
- [Iamgold pours first bullion at Côté project in Ontario.](#)
- [Proponents see northern Ontario's Ring of Fire opposition melting like ice roads.](#)
- [Gold Fields begins gold production at new Chilean mine.](#)
- [Scientists develop greener method for extracting gold from low-grade ore, e-waste.](#)
- [Paladin Energy kicks off commercial production at Namibia uranium mine.](#)
- Cesium: [The Rare Metal Keeping Biden and Xi Awake at Night.](#)

- [Gallium price has more than doubled since China export curbs.](#)
- ['It's had 1.1 billion years to accumulate': Helium reservoir in Minnesota has 'mind-bogglingly large' concentrations.](#)
- [Is It Time To Abandon the Idea of Phasing Out Oil and Gas?](#)
- [Is \\$100 Oil Within Reach?](#)
- Shoot yourself in the foot: [Canada 'not interested' in investing in LNG facilities, energy minister says.](#)

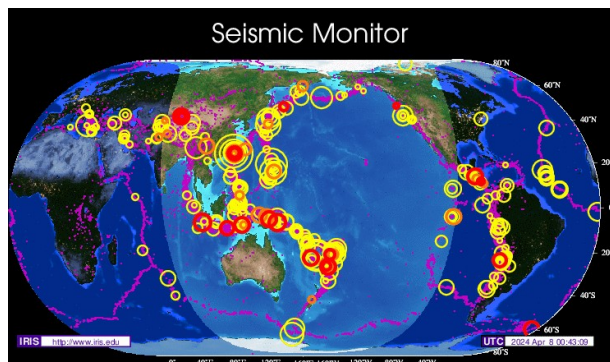
## Environmental Geology and Hydrogeology

- [Villagers near Madagascar mine take legal action against Rio Tinto.](#)
- [Per- and Polyfluoroalkyl Substances in Food Packaging: Migration, Toxicity, and Management Strategies;](#) Scientific American summary [here](#).
- [Defense and Protection of the Marine Coastal Areas and Human Health: A Case Study of Asbestos Cement Contamination \(Italy\).](#)

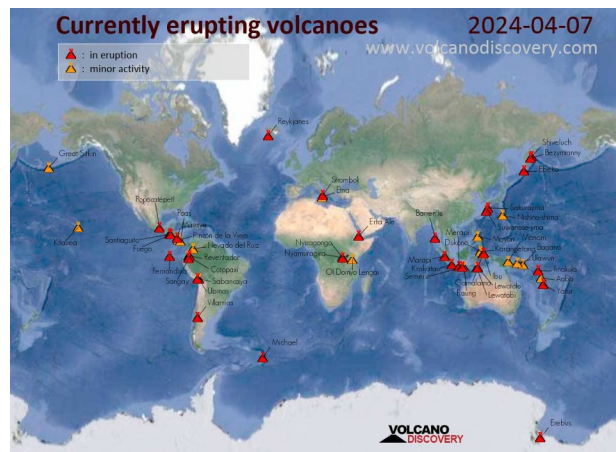
## Glaciers and Climate Change

- [Persistence of Holocene ice cap in northeast Svalbard aided by glacio-isostatic rebound.](#)
- [Abrupt cooling of cold seasons at the middle-late Holocene transition revealed by alkenone records from North China.](#)
- [Climate models can't explain 2023's huge heat anomaly – we could be in uncharted territory;](#) Phys.org summary [here](#).
- What could go wrong: [Geoengineering Test Quietly Launches Salt Crystals into Atmosphere.](#)

## Volcanoes, Earthquakes and Geohazards



[Seismic Monitor](#)



[Active Volcano Map](#)

- United States Geological Survey (USGS) Volcano Watch: [STEM and suction solutions at HVO](#).
- USGS Yellowstone Volcano Observatory: [The 1959 Madison Slide, Part 2: Recovery and remediation](#); part 1 [here](#).
- [Smithsonian / USGS Weekly Volcanic Activity Report](#).
- Iceland: [The magma is likely flowing from a depth of 15 km](#); Video: [Lava Spills Over Spatter Cone: April 7 Livestream with Geologist Shawn Willsey](#).
- Volcano research: [Submarine pyroclastic deposits from 7.3 ka caldera-forming Kikai-Akahoya eruption](#); Interesting Engineering summary [here](#).
- [Euro-Mediterranean Seismological Centre](#)
- [Earthquakes Monitoring Live Worldwide](#).
- Earthquake research: [The Main Factors Controlling Probabilistic Seismic Hazard Variability Due to Epistemic Uncertainty in Greece: Results from a One-Factor-at-a-Time Analysis](#).
- [Deadly M7.4 earthquake strikes Taiwan](#); USGS summary [here](#); [Video shows moments Taiwan hit by powerful earthquake](#); Video [shows desperate motorists dodging boulders](#).
- [M4.8 New Jersey earthquake shakes New England](#); USGS summary [here](#); New York Times summary [here](#); video [New Jersey Earthquake Update; The Largest Earthquake in 140 Years](#).

## Upcoming Events

- If you are in Calgary, AB for the Stampede: [Bootleggin' Breakfast 2024 – 100 Days To Stampede!](#)
- Today!!! [April 8](#) solar eclipse, NASA Eclipse Explorer [here](#).



[May 19-22, 2024](#)



**Goldschmidt is the foremost annual, international conference on geochemistry and related subjects, organized by the Geochemical Society and the European Association of Geochemistry**

April 8, 2024

## Geology and the Fate of Societies – Cote d’Ivoire



Figure 1 – Cote d’Ivoire

Credit: [CIA World Factbook, Cote d’Ivoire](#), public domain

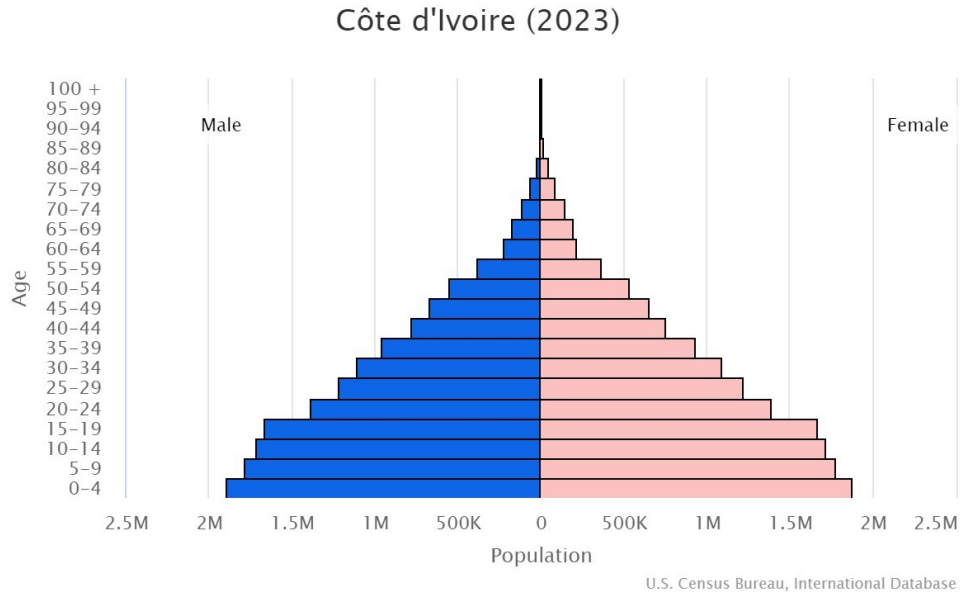
The [Republic de Côte d’Ivoire](#) is a former [French colony](#) on the [Gulf of Guinea](#) in [West Africa](#). Surrounding the Cote d’Ivoire, starting on the west and going clockwise are: [Liberia](#), [Guinea](#), [Mali](#), [Burkina Faso](#), and [Ghana](#).

According to the American [Central Intelligence Agency](#) (CIA) [World Factbook on the Cote d’Ivoire](#), the country has a total area of 322,463 square kilometres (km<sup>2</sup>) of which 318,003 km<sup>2</sup> are land and 4,460 km<sup>2</sup> are water.

Also according to the CIA World Factbook, 29,344,847 people live in the Cote d’Ivoire. Of that approximately 29.3 million Ivoirians, 28.9% are ethnic [Akan](#), 16.1% are [Voltaïque or Gur](#), 14.5% are Northern [Mandé](#), 8.5% are [Kru](#), 6.9% are Southern [Mandé](#), 0.9% are of unspecified ethnicity, and 24.2% are non-Ivoirian.

[French](#) is the official language although [Bété](#), [Baoulé](#), [Dioula](#), [Dan](#), [Anyin](#), and [Cebaara Senufo](#) are widely used. The country is religiously diverse: 42.9% are [Muslim](#), 17.2% are [Catholic](#), 11.8% are various [Evangelical Christians](#), 1.7% are [Methodist](#), 3.2% follow other [Christian](#) denominations, 3.6% adhere to [animist](#) beliefs, 0.5% follow other religions, and 19.1% say they have [no religion](#).

The [demographics of Cote d’Ivoire](#) show a young country, the median age for both sexes is 21 years. The total fertility rate is 3.47 births per woman, the annual population growth rate is 2.2%, and the life expectancy for both sexes is 62.7 years.



**Figure 2 – Demographic Structure of the Cote d’Ivoire**  
**Credit: U.S. Census Bureau, International Database, Cote d’Ivoire, public domain**

The Cote d’Ivoire is a [unitary presidential republic](#). The current President is [Alassane Ouattara](#), the Vice President is [Tiémoko Meyliet Koné](#) and the Prime Minister is [Robert Beugré Mambé](#). The [parliament](#) includes an upper house, the [Senate](#), and a lower house, the [National Assembly](#). The Capital City is [Yamoussoukro](#) (pop. 422,072 in the district) and the largest city in the country is [Abidjan](#) (pop. 6,321,017).

## Geology



**Figure 3 – Cratons in South America and Africa during the Mesoproterozoic**  
**Credit: Woudloper, Creative Commons Attribution-Share Alike 3.0 Unported, 2.5 Generic, 2.0 Generic and 1.0 Generic license**

The geology of the [Cote d'Ivoire](#) consists almost entirely of [Precambrian](#) aged crystalline rocks of the [West African Shield](#) overlain by younger sedimentary deposits only on the coastal plain in the southeast.

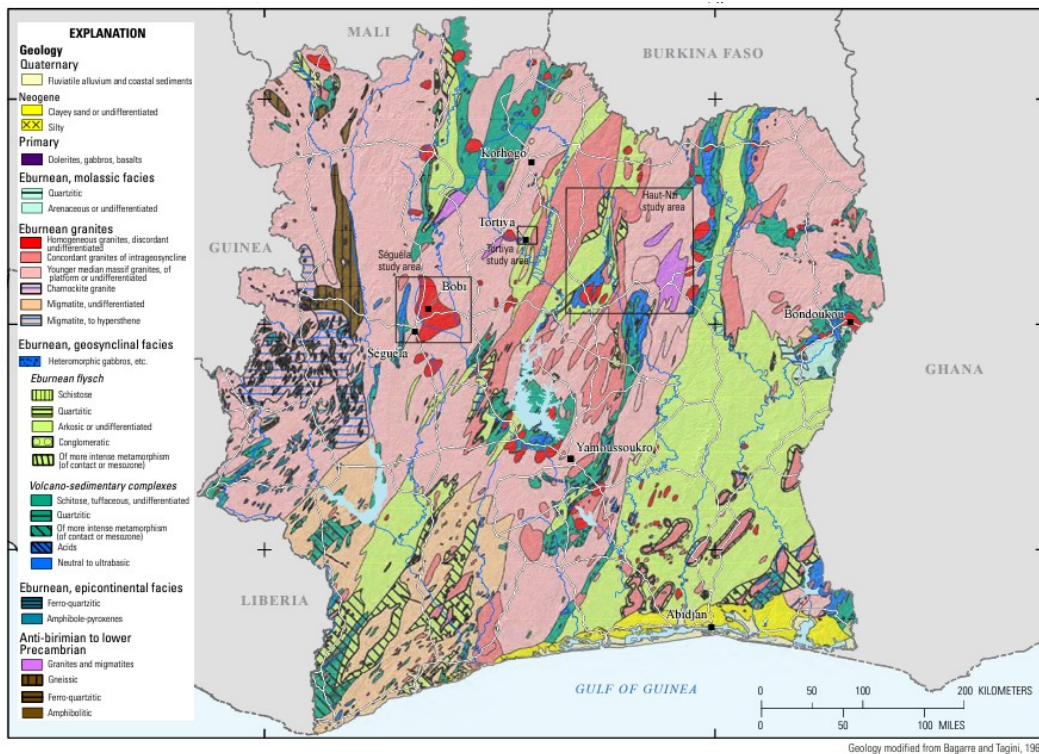
The younger sedimentary deposits consist of two main types:

- The youngest deposits are [Quaternary](#) aged [clay](#) interbedded with [sand](#) lenses, overall about 10 m thick; these are found along the southeast coastal plain.
- The next older group of deposits are [Neogene](#) aged deposits of the [Continental Terminal Formation](#).

The rocks of the West African Shield consist of two main groups:

- The youngest basement rocks are [Proterozoic](#), generally [Paleoproterozoic](#) in age and generally consist of metamorphic rocks, generally of sedimentary origin; these deposits are generally [schist](#), with [metasandstone](#) and [metaconglomerate](#) in some places; there also [granite](#) intrusions, as well as [tuff](#), [breccia](#), and [greenstone](#); these form folded bands running from north-northeast to south-southwest formed during the [Eburnean orogeny](#).
- The oldest basement formations include crystalline deposits of [gneiss](#), granite and [migmatite](#), mostly [Archean](#) in age. These deposits are most common in the west of the country, although migmatite deposits are ubiquitous.

Figure 4 shows the general geological map of Cote d'Ivoire.



**Figure 4 – Geology of the Cote d'Ivoire**  
 Credit: [Chirico & Malpeli, 2013, public domain](#)

## Resources

### Agriculture



Figure 5 – Woman Cultivating a Corn Field in Cote d’Ivoire

**Credit:** Melchisedek ABAKA, [Creative Commons Attribution-Share Alike 4.0 International](#) license

According to the CIA World Factbook on the Cote d’Ivoire, 64.8% of the land area is used for agriculture (9.1% [arable land](#), 14.2% [permanent crops](#), 41.5% [permanent pasture](#)), 32.7% is forest, and 2.5% has other uses. [Agriculture in the Cote d’Ivoire](#) includes two main sectors: [subsistence agriculture](#) and [cash crops](#). Crops raised for subsistence include: [yams](#), [cassava](#), [rice](#), [plantain](#) (cooking bananas), and [corn](#) (maize). Cash crops include: [cocoa](#), [sugar cane](#), [cashew nuts](#), [natural rubber](#), [banana](#), [cotton](#), [coffee](#), and [pineapple](#). The main livestock raised are [cattle](#) (for meat and dairy) and [chickens](#) (for eggs and meat).



Figure 6 – Zebu Cattle in the Cote d’Ivoire

**Credit:** Bound8, [Creative Commons Attribution-Share Alike 3.0 Unported, 2.5 Generic, 2.0 Generic and 1.0 Generic](#) license.

You can find the statistics from the United Nations Food and Agriculture Organization (FAO) for agriculture in the Cote d'Ivoire [here](#).

The Cote d'Ivoire is a [poor country](#) where 46% of people live below the poverty line of US\$1.22 (!!!) per day. Hunger and food insecurity has measurably dropped over the past 17 years from 3.8 million undernourished people in 2007 to 2.1 million in the years 2020 to 2022. As of the years 2020-2022, 44.2% of the population suffered from moderate and severe food insecurity.

### ***Forestry***



**Figure 7 – Forest in the [Banco National Park](#), Cote d'Ivoire**  
**Credit:** Emmanuel Grebo, [Creative Commons Attribution-Share Alike 4.0 International](#) license

According to the CIA World Factbook, about 32.7% of the land in Cote d'Ivoire is forest. According to the [European Union's Interactive Country Fiches](#), 90% of the natural forest cover in the Cote d'Ivoire has been deforested over the past 60 years. This includes land cleared for agriculture, both cash and subsistence, as well as land cleared for pasture land. Also included in that 90% figure are second growth forest and plantations such as those for cocoa, coffee and rubber. A consequence of this has been a significant drop in forestry production.

### ***Mineral Production***

A major part of mineral production in the Cote d'Ivoire is the production of natural gas, crude petroleum, and petroleum products. Other mineral commodities that are also important include: [bauxite](#), diamond, gold, manganese, and silver. Industrial mineral production includes aggregate (crushed granite) and cement production.

The petroleum and natural gas are from the [Baleine](#), [Baobab](#), [Espoir](#), [CI-103](#), and [CI-401](#) oil and gas fields; all these fields are offshore in the Gulf of Guinea. Bauxite production is from the [Benene mine](#). Diamond production is largely from artisanal production with no single mine identified. Gold is also produced in artisanal operations, as in the children mining in Figure 8, but also in five larger mines:

[Agbaou Mine](#), [Bonikro Mine](#), [Ity Mine](#), [Tongon Mine](#), and the [Yaoure Mine](#). The Bonikro mine also produces silver.



Manganese production is from two mines: the [Lauzoua-Mokta Mine](#) and the [Bondoukou Mine](#).

The use of child labour in mining is a regrettable consequence of the general poverty of many Ivorians, 46% of the people live on less than US\$1.22 per day, as well as the great availability of young people in a country where almost 60% of the populace is younger than 25.

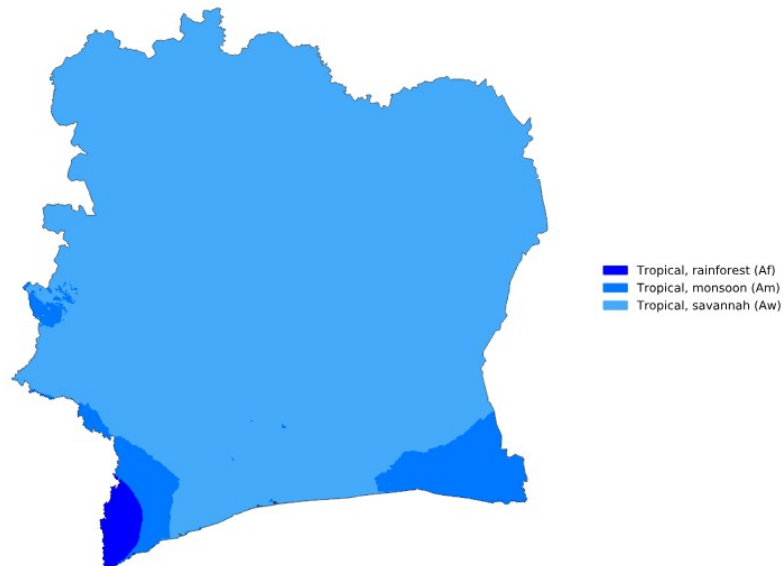
Still, I can think of better ways of developing the potential of these young people than putting them to work in the mines.

Statistics and further information on mineral production in the Cote d'Ivoire from the USGS can be found [here](#).

**Figure 8 – Child Labour in Artisanal Gold Production, 2024, Cote d'Ivoire; Credit: Ydiomande, Creative Commons CC0 1.0 Universal Public Domain Dedication**

## Climate

Köppen-Geiger climate classification map for Côte d'Ivoire (1980–2016)



Source: Beck et al.: Present and future Köppen-Geiger climate classification maps at 1-km resolution, Scientific Data 5:180214, doi:10.1038/sdata.2018.214 (2018)

**Figure 9 – Köppen-Geiger Climate Map of the Cote d'Ivoire**  
**Credit: Beck et al 2018, Creative Commons Attribution-Share Alike 4.0 International license**

The Cote d'Ivoire has a [tropical climate](#) with three main divisions:

- Tropical rainforest, [Af](#);
- Tropical monsoon, [Am](#); and
- Tropical savanna, [Aw](#).

If you would like to visit the Cote d'Ivoire, you might want to consider these travel advisories [here](#) and [here](#). The northern areas of country are especially dangerous due to [terrorist activity](#). Diseases common in the country include [malaria](#), [dengue fever](#), [hepatitis B](#), [schistosomiasis](#), [rabies](#) and [meningococcal meningitis](#). If you plan to live on the wild side in your visit, common sexually transmitted diseases, besides hepatitis B, include [HIV/AIDS](#).

## History and Geopolitics

### *History – The Coast Where You Buy Ivory (and Slaves)*

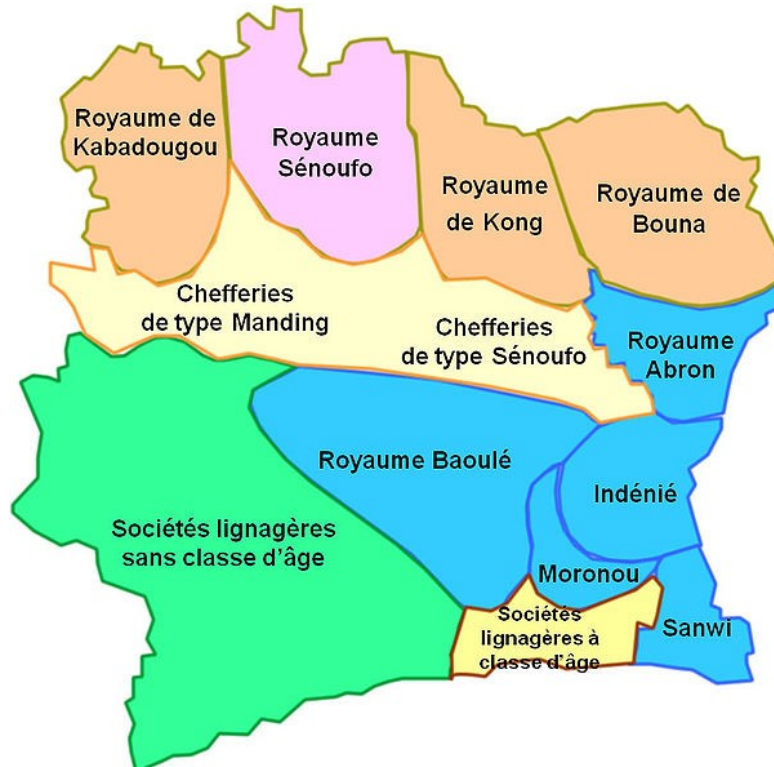


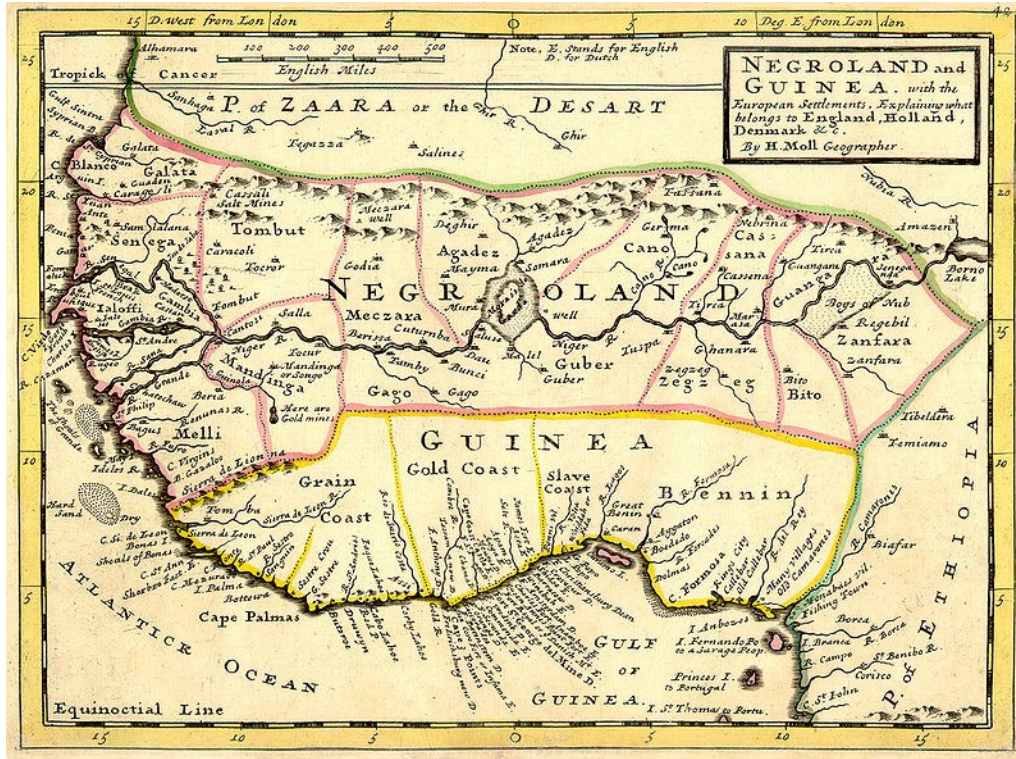
Figure 10 – Pre-colonial Map of the Cote d'Ivoire

Credit: [Zenman](#), [Creative Commons Attribution-Share Alike 3.0 Unported](#), [2.5 Generic](#), [2.0 Generic](#) and [1.0 Generic](#) license

In the [history of Cote d'Ivoire](#), there is little information available on the earliest inhabitants. The northern areas of the country were visited by Islamic traders from the [Sudanic](#) empires such as those of [Ghana](#) and the [Songhai Empire](#). Five important states flourished in Ivory Coast in the pre-European era:

- The [Bono](#) kingdom of [Gyaman](#);

- The [Baoulé](#) kingdom at [Sakasso](#);
- The two [Agni](#) kingdoms, [Indénié](#) and [Sanwi](#); and
- The [Kong Empire](#).



**Figure 11 – The 18<sup>th</sup> Century Slave Coast**  
**Credit: Herman Moll, public domain**

Europeans began trading along the south coast in the 15<sup>th</sup> and 16<sup>th</sup> Centuries, beginning with the [Portuguese](#). The Europeans tended to name the places along the Gulf of Guinea after the commodities available there – so you had [the Grain Coast](#), the [Gold Coast](#) and the [Slave Coast](#). The area around the modern city of Abidjan got the name Ivory Coast or, in French, Cote d’Ivoire.

While [French](#) adventurers first visited the Cote d’Ivoire in 1483 and they established various trade posts in West Africa in the 16<sup>th</sup>, 17<sup>th</sup> and 18<sup>th</sup> Centuries, the French really began to take a close interest in the country when, in 1843–1844, the French admiral [Bouët-Willamez](#) signed treaties with the kings of the [Grand Bassam](#) and [Assini](#) regions, placing [these territories](#) under a French protectorate i.e. we make you an offer you cannot refuse. By 1880, the French had established effective control of the Cote d’Ivoire. In 1904 Côte d’Ivoire became part of the [Federation of French West Africa](#).

The French ruled the Cote d’Ivoire as part of their [African Empire](#) until 1960, when the country was granted independence. The post-colonial history of Cote d’Ivoire has not been entirely peaceful.

From [1960 to 1999](#), under the rule of first [Félix Houphouët-Boigny](#) and then [Henri Konan Bédié](#), the Cote d’Ivoire maintained a somewhat stable polity, however, one marked by one party rule and the consequent

corruption of such rule. In 1999, a military junta led by General [Robert Guéï](#) overthrew the government in the [1999 Ivorian coup d'état](#).

General Guéï was succeeded by [Laurent Gbagbo](#) in October 2000 after an election where Guéï initially contested the validity of the election. Things got worse and by 2002 a [civil war](#) broke out that lasted until 2007. At the heart of the civil war was the divide between the predominately Muslim north and the predominately Christian and Animist south. Resolution of the civil war involved intervention by French forces.



**Figure 12 – French Soldiers of the 1<sup>er</sup> RHP in the Cote d’Ivoire in 2003**  
**Credit: [Supercopter](#), [Creative Commons](#) Attribution-Share Alike 3.0 Unported, 2.5 Generic, 2.0 Generic and 1.0 Generic license**

A contested (crooked?) election in 2010 led to a [second civil war](#) that lasted from November 2010 to April 2011. The current President, Alassane Ouattara, engineered a [change in the constitution](#) in 2016 that allowed him to run for a third term in office. Following this constitutional change, there was an attempted [coup d'état in 2017](#) when unpaid soldiers mutinied. Ouattara, however, survived the coup attempt. In November 2020, Ouattara won third term in office in [elections](#) boycotted by the opposition. Currently, the country enjoys an uneasy peace under Ouattara’s rule.

## Geopolitics – A Troubled State



**Figure 13 – Photo of Abidjan from its Lagoon**

**Credit:** [Hermannkass](#), [Creative Commons Attribution-Share Alike 4.0 International](#) license

Underlying the uneasy peace in the Cote d’Ivoire are a number of serious issues that could keep the country unstable for years or possibly break it up, these include:

- The already noted division between the Muslim north and Christian/Animist south; this kind of religious divide will always be a source of friction in the country;
- [Terrorist activity](#) in the north, mostly the work of [Islamist gangs](#), although these attacks have [dropped off](#) in the last two years;
- The [corruption](#) that results from the rule of a single person and his party for a long time; that’s why they wrote term limits into their constitution; and
- Ongoing [poverty](#) and a failure to develop their most precious resource – their people; kids working in placer mining operations are not in school learning more broad based skills that would improve their lives and make them more economically productive.

It is possible that the ongoing [leadership of Alassane Ouattara](#) is necessary to keep order in the Cote d’Ivoire so that some improvements can be made. Or maybe not. These kind of arrangements have a way of developing into sophisticated (or blatant) schemes to rob a country blind in order to enrich a favoured group that mostly includes the country’s leadership.

The relations between the Cote d’Ivoire and its neighbours are currently peaceful:

- Cote d’Ivoire and Liberia have entered into a [cross-border cooperation project](#);

- Côte d'Ivoire, Liberia, Sierra Leone, and Guinea have entered into an [agreement](#) to interconnect their power grids;
- Cote d'Ivoire's relationship with Mali and Burkina Faso is clouded by the activities of Moslem [Jihadists](#) in those two countries; and
- The relations between Ghana and Cote d'Ivoire are generally peaceful, but are clouded by a [maritime border dispute](#) – this dispute is strongly related to off-shore petroleum exploration and production; see the oil lease map below.

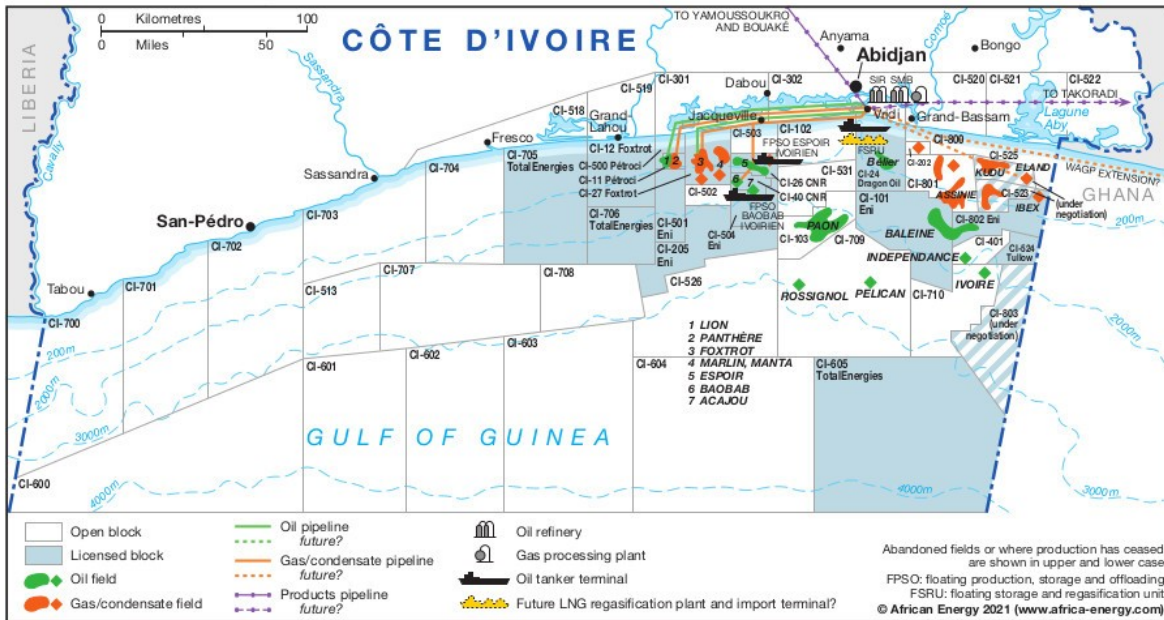


Figure 14 – Cote d'Ivoire Oil & Gas Leases, Gulf of Guinea, 2021  
 Credit: ©Africa Energy

Another outside power that continues to take an active role in Ivorian affairs is the former colonial power, France. As noted above, [French troops intervened](#) to support government forces during the 2002 – 2007 civil war and they [may be called upon to do so again](#).

Further afield, the natural resources of the Cote d'Ivoire, especially its offshore petroleum reserves, may become a tempting target for powers such as [China](#) and the [United States](#). [Russia](#), through its [mercenary organization, the Wagner Group](#), may also become involved.

Overall, the Cote d'Ivoire is a troubled state (36 out of 179 on the [Fragile State Index](#)). My opinion is that its people deserve better government than they have been getting and that the root of many of the country's troubles lie at the feet of its corrupt ruling class.

That kind of winds up this short look at the Cote d'Ivoire. Follow up in the links if any of this interests you.

## Standard Caveat

The purpose of my weblog postings is to spark people's curiosity in geology. Don't entirely believe me until you've done your own research and checked the evidence. If I have sparked your curiosity in the subject of this posting, follow up with some of the links provided here. If you want to, go out into the field and examine some rocks on your own with the help of a good field guide. Follow the evidence and make up your own mind.

In science, the only authority is the evidence.