

October 2, 2023

News and notes

Before going on to discuss the geology and geopolitics of [Bhutan](#), here are some news items I thought were interesting.

Research

- Education: [A Web Tutorial for the Petrographic Analysis of Carbonate Rocks](#).
- From Judith Hubbard's website: [Printable wall map of Morocco](#).
- Regional geology: [Subsurface geological and geophysical data from the Po Plain and the northern Adriatic Sea \(north Italy\)](#).
- More regional geology: [Provenance of a Late Permian retroarc foreland basin along the eastern Gondwanan margin: northern Sydney Basin, eastern Australia](#).

Geophysics

- [Characteristics and longitudinal extent of VLF quasi-periodic emissions using multi-point ground-based observations](#).
- [Understanding the Ries impact structure subsurface from high-resolution seismic data](#).
- [Radial shear in the flow at the Earth's core surface](#).

Plate Tectonics

- [Reconnaissance basement geology and tectonics of North Zealandia](#); Phys.org summary [here](#).
- [Structure and morphology of an active conjugate relay zone, Messina Strait, southern Italy](#); Phys.org summary [here](#).

Paleontology

- [Polar bear's range dynamics and survival in the Holocene](#); Phys.org summary [here](#); related research [here](#).
- [Preservation of corneous \$\beta\$ -proteins in Mesozoic feathers](#); Sci Tech Daily summary [here](#).
- [Uniquely preserved gut contents illuminate trilobite palaeophysiology](#); Phys.org summary [here](#).
- [A Bayesian inversion for emissions and export productivity across the end-Cretaceous boundary](#); related discussion in Wired: [An Epic Fight Over What Really Killed the Dinosaurs](#).
- Evolution: [Accelerated body size evolution in upland environments is correlated with recent speciation in South American freshwater fishes](#).
- More on fish evolution: [Cycles of fusion and fission enabled rapid parallel adaptive radiations in African cichlids](#); Phys.org summary [here](#).
- Fossil animal tracks: [Basal sauropodomorph locomotion: ichnological lessons from the Late Triassic trackways of bipeds and quadrupeds \(Elliot Formation, main Karoo Basin\)](#).

Environmental Geology and Hydrogeology

- Remediation research: [An archaeal lid-containing feruloyl esterase degrades polyethylene terephthalate](#); Phys.org summary [here](#).
- More remediation research: [Kinetics and Mechanism of Ultrasonic Defluorination of Fluorotelomer Sulfonates](#); Phys.org summary [here](#).
- Mine tailings remediation: [Nitrogen-Rich Organic Matter Formation and Stabilization in Iron Ore Tailings: A Submicrometer Investigation](#); Phys.org summary [here](#).
- [Understanding the phenomenon of saltwater intrusion sourced from desalination plants at coastal aquifers](#).
- ["Wrecking the rocks": Continental weathering by groundwater](#).
- **Free text book** for download from the Groundwater Project: [Stable Isotope Hydrology](#).

Mining and Energy

- Zimbabwe: [Road construction workers stumble on 'huge' lithium deposits](#).
- [Start date for British Columbia's largest gold mine is 2024](#).
- Geochemistry and mining exploration: [Kaolinite clay makes a great face mask, but it may hold key to location of gold and critical minerals](#).
- ['This is a milestone': Poland's environment agency greenlights country's first nuclear power plant](#).
- [Texas Molten Salt Nuclear Reactor Planned for 2026](#).
- [Britain approves huge, controversial oil and gas field in the North Sea](#); it is only controversial if you don't mind freezing in the dark.
- [US drillers cut oil and gas rigs for third quarter in a row -Baker Hughes](#).
- [Oil Prices Set For Another Weekly Gain Despite Falling Back](#).

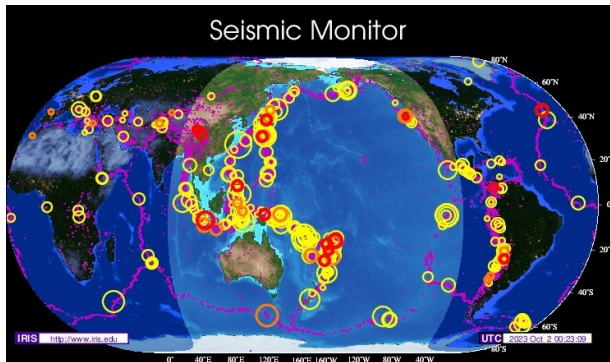
Carbon Capture

- [Cooperative Copper Single Atom Catalyst in Two-dimensional Carbon Nitride for Enhanced CO₂ Electrolysis to Methane](#); Phys.org summary [here](#).
- [Photocatalytic methane conversion to high-value chemicals](#); Phys.org summary [here](#).
- [Bioelectrocatalytic CO₂ Reduction by Mo-Dependent Formylmethanofuran Dehydrogenase](#); Phys.org summary [here](#).
- [Direct conversion of methane with O₂ at room temperature over edge-rich MoS₂](#); Phys.org summary [here](#).
- [Is water activity the elephant in the room?](#) (behind a paywall).

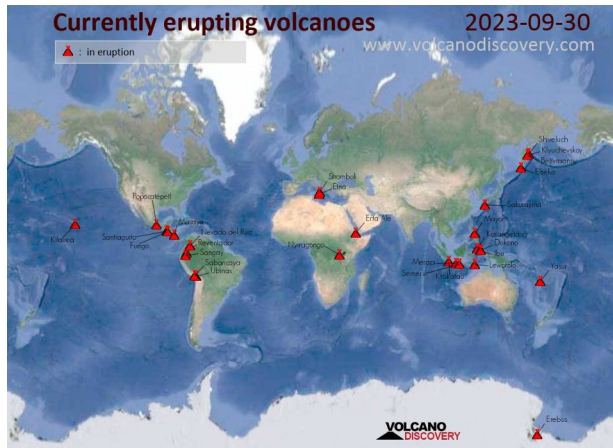
Glaciers and Climate Change

- [Modes of Antarctic tidal grounding line migration revealed by Ice, Cloud, and land Elevation Satellite-2 \(ICESat-2\) laser altimetry](#); Phys.org summary [here](#).
- [How fast are Arctic glaciers melting? Engineers explored the north with a robot and cameras to find out](#).
- [Humid phases on the southwestern Arabian Peninsula are consistent with the last two interglacials](#).

Volcanoes, Earthquakes and Geohazards



[Seismic Monitor](#)



[Active Volcano Map](#)

- United States Geological Survey (USGS) Volcano Watch: [What do we know about the Kulauea Tephra of Kilauea volcano?](#)
- [Smithsonian / USGS Weekly Volcanic Activity Report](#).
- [Fire From Volcanic Activity: Quantifying the threat from an understudied hazard](#); Phys.org summary [here](#).
- [On a large magmatic fluid reservoir oblique to the volcanic front in the southern part of NE Japan revealed by the magnetotelluric survey](#).
- [A multifault earthquake threat for the Seattle metropolitan region revealed by mass tree mortality](#); Phys.org summary [here](#); summary in Scientific American [here](#).
- [Role of fluid on seismicity of an intra-plate earthquake zone in Western India: an electrical fingerprint from magnetotelluric study](#).
- [Identification of active faults and tectonic features through heat flow distribution in the Nankai Trough, Japan, based on high-resolution velocity-estimated bottom-simulating reflector depths](#).
- [Assessing the reliability of local earthquake tomography for crustal imaging: 30 years of records in the Western Alps as a case study](#).

October 2, 2023

Geology and the Fate of Societies – Bhutan



Figure 1 – Map of Bhutan

Credit: [CIA World Factbook](#), public domain

The Kingdom of [Bhutan](#) (Druk Gyal Khap in the official national language, [Dzongkha](#)) is located in the [Eastern Himalayan Mountains](#) between [India](#), to the south, and [China](#), to the north. Immediately south of a narrow 50 km corridor in the [Indian State of Assam](#), is [Bangladesh](#). According to the [CIA World Factbook](#) on Bhutan, the country has a total area of 38,394 square kilometres, all of it land with negligible water (1.1% of the total area).

The [current estimate of population](#) is 876,181 people. The ethnic breakdown of Bhutan is as follows: [Ngalop](#) (also known as Bhote), 50%; [Nepali](#), 35% (predominantly [Lhotshampas](#)); and other indigenous or migrant tribes, 15%. Languages spoken in Bhutan include [Shar chopkha](#) 28%, [Dzongkha](#) (official) 24%, [Lhotshamkha](#) 22%, and other 26% (includes foreign languages).

[Vajrayana Buddhism](#) is the official state religion of Bhutan, followed by about 84.3% of the country's population. Other religions in Bhutan include [Hinduism](#) (11.3%), [Bon](#) (3.2%), Christianity (0.7%) and other (0.5%).

Bhutan is a [constitutional monarchy](#) with a [bicameral legislature](#). The head of state, [Druk Gyalpo](#) (King) [Jigme Khesar Namgyel Wangchuck](#) exercises considerable authority under their system. The capital and largest city is [Thimphu](#) (population 114,551).

Geology

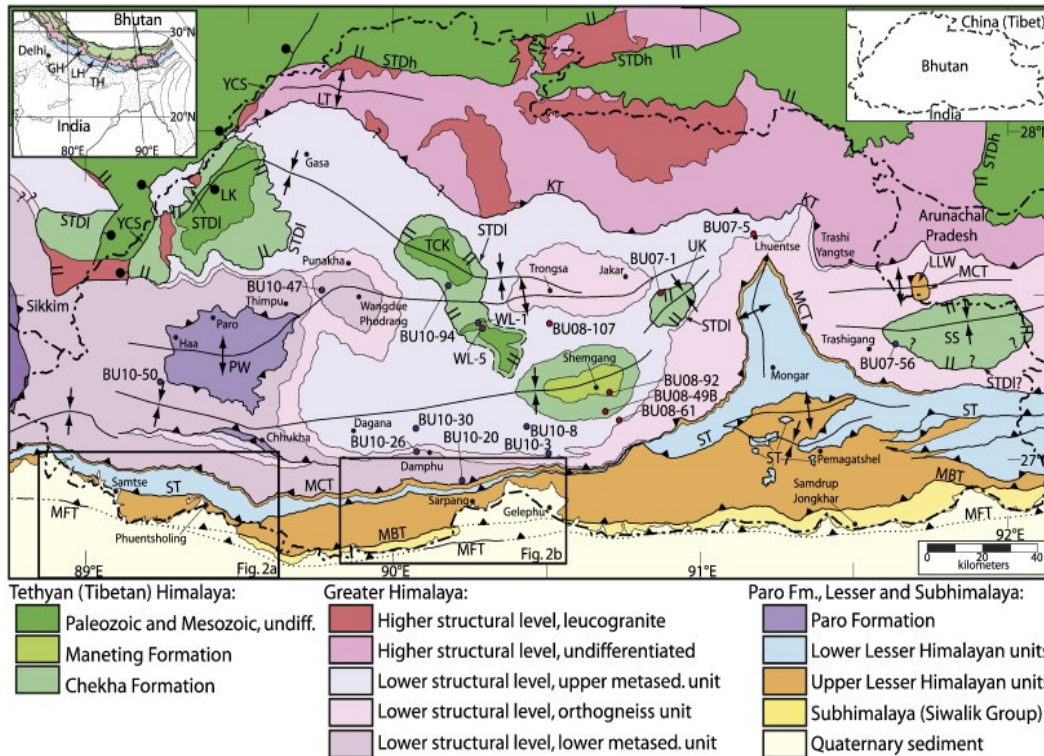


Figure 2 – Geology of Bhutan

Credit: Figure 1 in [McQuarrie et al 2013](#),
[Creative Commons Attribution-Share Alike 3.0 Unported license](#)

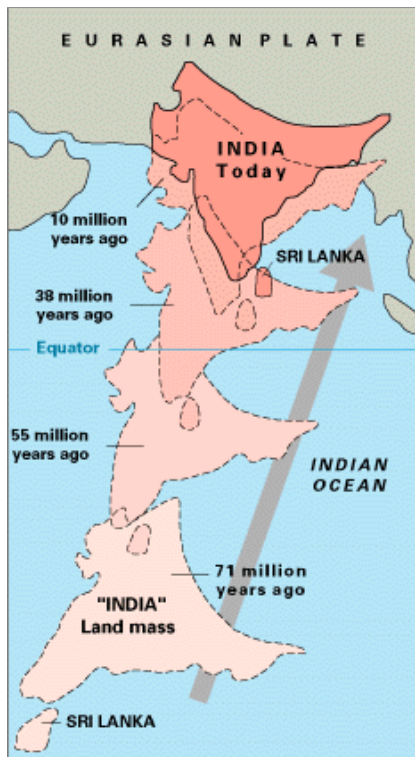


Figure 2 shows the general [geology of Bhutan](#). The major mountain building episode in the geological history of Bhutan was the [Himalayan Orogeny](#) where the [Indian Plate](#) collided with the [Eurasian Plate](#). The process began about 140 million years ago, with the breakup of [Gondwana](#), when the Indian Plate began moving northwards toward the Eurasian Plate. By 50 million years ago, during the [Eocene](#), the two plates came into contact with one another, beginning the lifting of the [Himalayan Mountains](#), a process that continues till today. Figure 3 summarizes the collision of the two plates over time.

Figure 3 – Collision of the Indian and Eurasian Plates
Credit: USGS, [public domain](#)

There are three main divisions in the geology of Bhutan, as shown on Figure 2:

- [Paleozoic](#) and [Mesozoic](#) deposits that originated in the [Tethys Ocean](#), including the [Maneting and Chekha formations](#);
- Metamorphic rocks of the [Greater Himalaya Sequence](#); and
- The remaining units include: the [Paro Formation](#), the Upper and Lower [Lesser Himalayan Sequence](#), the [Siwalik Group](#), and the [Quaternary Sediments](#).

The geology of Bhutan is fairly complex. If you are interested, follow up on some of the links for a better description, a good starting point is [McQuarrie et al 2013](#).

Resources

Agricultural Resources

13.6% of the land in Bhutan is used for agriculture and about 80% of Bhutan's population is directly involved in [food production](#). Major crops include maize and rice. Other crops include wheat, barley, oil seeds, potato, and various vegetables. Among vegetables, chili and potato are most important. In addition, apple, orange, and cardamom are grown as cash crops. [Animals raised](#) include yaks, cattle, hogs, sheep and goats.

Statistics on agricultural production can be found [here](#). Overall, Bhutan suffers from [serious food insecurity](#). About half the food consumed in the country is imported and about a quarter (27%) of households cannot afford basic nutrition. As a result, 1 in 5 children are stunted in their growth. Researchers claim that things [are getting better](#), however.

Forestry



Figure 4 – Forests in Bhutan

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

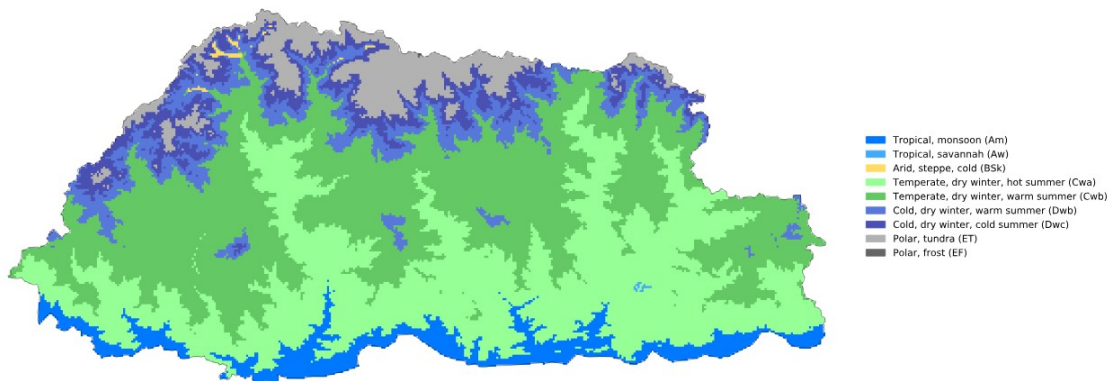
[Bhutan's forests](#) cover 85.5% of the land and are predominately oak and pine with some tropical hardwoods. The traditional uses of the forest for firewood and building continue to this day. Forestry is strictly regulated for both conservation and prevention of soil erosion.

Mineral Resources

The USGS report on mineral resources in Bhutan combines it with Nepal in [The Mineral Industries of Bhutan and Nepal – 2019](#). The major products were [cement](#), [bituminous coal](#), [ferrosilicon](#), [gypsum](#), [iron ore](#), [building stone](#) and [talc](#). The statistics for production are in the USGS report noted above.

Climate

Köppen-Geiger climate classification map for Bhutan (2071–2100)



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 5 – Köppen-Geiger Climate Map of Bhutan

Credit: Beck et al, 2018, Creative Commons Attribution 4.0 International license

[The climate of Bhutan](#) is largely controlled by elevation with [tropical monsoon](#) at the lower elevations and [polar tundra](#) at the highest elevations. Much of the country has a [temperate climate](#), with most of the annual rainfall falling during the [monsoon](#) season.

History and Geopolitics

The [history of Bhutan](#) involves obscure events for the settlement of the country by people speaking [Tibetan languages](#) sometime around 2000 BC. The major events in Bhutanese history are:

- The introduction of Buddhism from India in the 7th century;
- The consolidation of the Kingdom in 1619 and the defeat of a Tibetan invasion;
- Disputes with British India in the 1800's;
- Establishment of the current Wangchuck dynasty in 1907; and
- The proclamation of the modern constitution in 2005.

An interesting aspect of modern Bhutan is their [promotion of Gross National Happiness over Gross Domestic Product](#). Essentially, they look at the real effects of economic changes on their people to guide

their national policy. As noted above, Bhutan has serious issues with poverty and especially food security, so the Gross National Happiness policy still has a way to go.

Geopolitically, Bhutan is a relatively small and poor nation sandwiched between two world powers, China and India. China, to their north, may frighten Bhutan the most based upon the [brutal conquest of Tibet by the Chinese](#) in 1959. India, to the south of Bhutan, may be another problem in the future. India has a lot of other concerns, not least of all is [their dispute with China](#). Also, problems in India sometimes spill over in Bhutan as in the [2003 campaign against Assamese separatists](#) who set up armed base-camps in Bhutan.

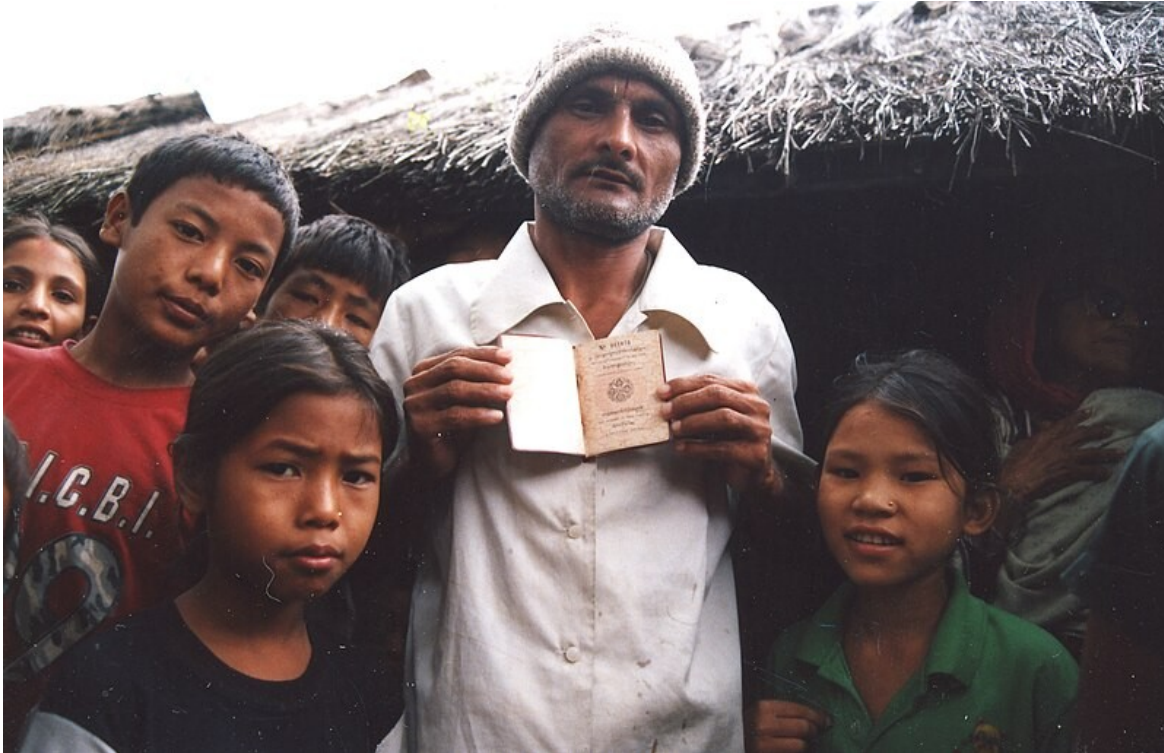


Figure 6 – Lhotshampa Refugees in Beldangi Camp
Credit: Alemaugil, [public domain](#)

Another issue for Bhutan has been [their past treatment of Nepali inhabitants](#). In 1988, Bhutan evicted Nepali, predominantly Lhotshampa, residents. The total number is in dispute, Bhutan claims 5,000, refugee advocates say up to 100,000. The refugees set up camps in [Nepal](#) and the Indian state of [Sikkim](#). [This dispute](#) has yet to be settled.

That makes for a short look at the geology and geopolitics of Bhutan. If this interests you, follow up on the links. If you want to go to see Bhutan, [be warned](#) that it is expensive and that the Bhutanese government is hesitant about allowing visitors into the country.

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.