

Between the Atmosphere and the Abyss

TOWARDS THE CONTINENTAL SHELF

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We live on a planet that appears, at first glance, to be binary in nature. There is land, and there is sea. The continents are the inverse of the ocean. The land stands out on the map as dry earth clearly divided from blue water. Yet the coast is as diverse as it is variable.

Let's explore the edge of Asia, and use the power of imagination to conduct a long transect of this transitional zone. We'll travel overland from the mountains to the beach, and along the way appreciate the diversity of the coastal terrain. We'll splash in the waves at the tide line, and then explore the shallow waters of the continental shelf.

We'll move out into deeper water, as well, and pause at the true edge of the continent. Observing the changes there, we'll then descend into the abyss, and beyond the edge to new realms of strange biologies and hidden geology.

Change Is Constant

The coastline, or the littoral zone, changes constantly and rhythmically with the tides, ominously with the melting polar ice caps, and catastrophically with tsunamis.

The coastline that we recognise on our maps is only an averaged observation of current conditions. The outlines of dry land have always been in perpetual motion. Tectonic plates

drift and land masses move, glaciers freeze and melt, and the amount of water in the oceans changes. River delta sediments settle and subside, and volcanic regions spill forth material from deep within the Earth.

Reconstructions of past global geography have been pieced together by geologists and geomorphologists – these maps show a curiously familiar set of continents. On the other hand, if you left the planet and returned in a thousand years, you would observe yet another altered configuration of water and land.

Our Journey Begins

We find ourselves in the uplands of the continent. The Earth's highest altitudes come close to 9,000 metres above the (historical) average sea level. Coincidentally, the atmosphere at this level is about the thinnest at which there is sufficient oxygen to support human life.

We'll then travel down, towards the Earth's core. Following the path of a raindrop, we spill down cliff lines, race down mountain streams, and then meander our way along the course of the river to approach the coastline of Asia.

The coastline is graced by sandy beaches, pierced by outflowing rivers and emboldened by sheer cliffs. It has been altered by urbanisation, cut by gorges, and enlivened with



BELOW Beaches are the collection of sediments from terrestrial and aquatic processes





Akko, Israel, near Pisan port and St John's Church: The coastline appears relatively stable in urban areas, but has actually been moving over geological time

Two contrasting examples of intertidal organisms are mangrove trees and rock mussels.

mangroves. It stands out at capes and promontories, and falls inward at bays and harbours.

Between the Tides

The intertidal zone is a biologically rich environment where organisms thrive in a challenging, alternating environment. The intertidal area can be large, such as a vast river delta, or small, such as a rock platform at the base of ocean cliffs.

Over the course of a day, following a complex rhythm influenced by the pull of the moon, the water's edge moves between the upper shore at the high tide line, and the lower shore at the low tide line. Between these fluid, changing lines, only specially adapted organisms can persist. Others can visit temporarily, but must retreat as the tide changes.

Two contrasting examples of intertidal organisms are mangrove trees and rock mussels. The mangroves are a group of terrestrial plants that have adapted to saline conditions and can colonise flat, sediment-rich areas on the coastline. A mangrove provides energy to the ecosystem via photosynthetic leaves and creates habitat structure in its branching network of roots. It can tolerate the dry conditions at low tide and the saltwater flooding at high tide.

The mussels, and other seashells, are by contrast oceanic animals that have found a way to survive periods of dry air. These molluscs close up tight in their armoured shells and maintain their moisture. When the tide rises again they become active. Many of the seashells that you can see clinging

tightly to the coastal rocks will be mobile once they are back in their preferred saltwater environment.

Beaches, which are intermediate in nature between sediment deltas and rocky coastlines, have less visible wildlife in their sands. Their shifting composition forms a challenging environment relative to the deltas or the rocks, and the specialised organisms inhabiting the beaches are often burrowed out of sight.

Beyond the Familiar

As an exercise of the imagination, we can move beyond the familiar perspective of the dry land and visualise these geographies of the coastal environment as if we were creatures of the sea.

The beaches ramp up to the shore world, with sandy banks both above

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and below the intertidals. The rivers are avenues of freshwater and sediment flowing into the environment. The cliffs would perhaps rise up from the depths and offer us a vertical rocky environment to explore before it reaches the inaccessible surface.

The mangroves, from our aquatic perspective, are a tangle of roots and fallen leaves, with their green leaves visible, reaching towards the sun. At the capes, the land intrudes into our ocean, and at the bays, we gain new territory. By the cities, we swim in strange realms of wooden dock pilings, boat propellers and plastic litter.

The Shelf – The Sublittoral

We turn our attention away from the continent. The continental shelf stretches before us for almost a hundred kilometres. It is relatively shallow, less than 200 metres in depth and is abundant with oceanic life. Here, light streams down through the water column of the neritic zone and provides energy to fish, seaweeds, corals and countless other living things of the continental shelf.

Nutrition from the dry world comes down onto the shelf, streaming off of the continent in plumes and deltas of sediment. Larger, heavier grains of sand accumulate close to shore at the beach, and farther away, smaller particles of clay settle in a silty layer. These sediments are the material of the continents worn away and



The rocky fingers of the continent provide a safe harbour for mariners

brought to the ocean by the perpetual force of gravity.

The terrain of the continental shelf – the sublittoral – is generally low in relief. For all the seeming difference in biological character between the aquatic shelf and the terrestrial coastal plain, there is a fundamental similarity.

In previous times, when the Earth was colder, liquid water was trapped as ice at the planetary poles and the



LEFT Malaysian mangroves: An increase in mangroves has been suggested for climate change mitigation

RIGHT Sunset on Juhu Beach: The famous beach of Mumbai grows dramatically at low tide

BOTTOM Mangroves are adapted to saline conditions



sea level was lower. These continental shelves were then exposed to the atmosphere and were the flat coastal plains that we earlier traversed. There is clear topographical evidence of this in the form of rias, or flooded valleys. These appear as branching bays surrounded by hills, but a careful study of the slopes and patterns will show that it is drowned valley.

Daunting as it may be, we must accept that due to natural processes drastically quickened by human activities, the ice caps are melting and the ocean levels are rising. The coastal plain – home to so many of us and the site of so much history – will one future day be the part of the sublittoral.

The Slope and the Rise

A hundred kilometres offshore, we reach the true edge of Asia – the shelf break. This is the edge of the escarpment, and this is where the lighter granitic continental rock gives way to the heavier basaltic ocean floor. This is the edge of the tectonic

plate and the edge of the deep ocean. Before us is the descending continental slope and at the base of the slope is the continental rise, accumulated sediments and rockfall.

Around the globe, this edge is found at approximately 140 metres in depth. It's important to remember that the sea levels rise and fall in geological time. The continental break, therefore, may be a more consistent baseline measure of altitude than the average sea level.

Edges Around Asia

Asia, more than the other continents, has a coastline dominated by the sublittoral shelf environment. The northern, eastern and southeastern, and southwestern seaboard of Asia have broad shelf regions. These are relatively shallow seas, rather than deep ocean waters. This means, amongst other things, a shallow environment suitable for extensive coral reefs and a relatively accessible environment for accessing subaquatic subterranean fossil fuels.

Look at a map of Asia, and you'll see that only the regions near the east coasts of India, Arabia and Japan lack broad sublittoral shelves. For even greater contrast, compare the west coast of South America, where the deep ocean environment is adjacent to the mountainous coast, with the waters of Malaysia surrounded by continental shelf.

Ocean and Abyss

We have reached the true edge of the continent, and it is time to leave the shallow waters for the dark abyss. The ocean, the vast space between the landmasses, begins here.

A submarine canyon cuts into the continental break, and leads us down into the unknown. Distinct habitats for biological life, these canyons are found around the globe. These terrain features of the continental edge were formed by a variety of influences, including scouring by sediment in currents, by broad avalanches, or by slow gravitational processes.



FAR LEFT Leatherback turtle tracks: Intertidal zones can be marked by footprints only temporarily – the tide will soon rise up to the cliffs

LEFT Intertidal regions offer a vibrant and dynamic environment for exploration

BOTTOM LEFT The intertidal region is a zone of constant change and is a paradise for photographers

BOTTOM RIGHT A cliff line at the coast may indicate a steeply diving offshore environment

The pressure of several kilometres of liquid water weighs inexorably on us from above.

We exit the canyon onto the deep benthic environment. The pressure of several kilometres of liquid water weighs inexorably on us from above. Dark and distant from the sun's energy, there is far less biological material here.

Somewhere beyond, titanic seamounts rise towards the surface. Oceanic ridges spew out volcanic material while thermal seeps fuel isolated and bizarre biological communities. Rifts and trenches gouged by inconceivable geological stresses are gateways to even deeper, more mysterious kingdoms.

These alien realms are beyond the edge of the continent. We have travelled from atmosphere to abyss and have crossed over the edge. Our journey ends here. ♦ AG

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