

## From Trieste To Kotor

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### ABSTRACT

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The Dalmatian coast has been described by an occasional poet as the site where chalk and sea meet. If in frequent political turmoil, it also has shown to be equally an area of frequent geomorphologic events. The riparian countries have been trying, with some success, to make a tourism trump of what Emmanuel de Martonne appropriately labelled une côte morcelée. The paper focuses on the region's significance as a geomorphology "textbook".

**ADDITIONAL INDEX WORDS:** *Dalmatian coast, Poljes, Uvalas, karst.*

### INTRODUCTION

The coasts of Europe are mostly receding. Coastlines are modifying. If in some rare instances accretion occurs, even to the point that some cities are losing their significant to the sea, with dire economic consequences—Bruges and Brouage—and islands are "embodied" in the land—Cadzand and Belle-Isle—the major worry is that the level of the sea is steadily rising and has been for well over a century and a half. Beaches are a major agent on the tourism scene and coastal geologists, geographers, oceanographers and [economic] planners are searching for sustainable means to save the shores. The economic aspects are considerable.

Tourism is a big earner for the coastal cities and states of the former Yugoslavia. And though the rise of sea-level to be expected is minimal, the damage that would be inflicted upon tourism infrastructures and historical towns would create huge financial hardships. It will thus not surprise anyone that major studies are being conducted in Europe, to which a forthcoming book bears witness; the Eastern coast of the Adriatic Sea is not absent from the volume and this paper aims at lifting a veil that may be subduing too much the regional scenario.

Bosnia-Herzegovina, Croatia, Montenegro, Slovenia are the only political entities resulting from the implosion of the former Yugoslav Federative Republic that are not landlocked. Though without an actual exutory to the sea, Serbia partakes, in its extreme southwestern portion, of the Dinaric coastal system. Dalmatia is part of Croatia, Istria belongs to Slovenia, and Slavonia straddles Croatia and Slovenia. The Dalmatian type coast of the Eastern Adriatic is predominantly located in Croatia.

If the former Yugoslavia was a remarkable mosaic of cultures, religions, languages, ways of life which no administrative sleight of hand could ever unify, its physical geography was as remarkable as a picture of similarity. The coastal area was no different. Some dominant features encompass poljes, dolines,

grottoes, karst. They are found in all of the states that share the Dalmatian coast, on the eastern side of the Adriatic Sea.

The country is made up of three physical units: Podravina, Prosavina and Slavonia. Major features of the Dinaric Alps—which parallel the Dalmatian coast—are Kordum, Gorski Kota, the Velebit Range and the poljes. Polje, occasionally spelled polye, is Serbo-Croatian meaning plain, by extension depression. It is a broad hollow surrounded on all sides by steep sided rocky ridges. Alluvial by origin, the polje is flat bottomed and may be dry or periodically flooded; however, poljes are often the site of lakes. Sizes vary but some poljes stretch over considerable distance or conversely are quite wide.

The doline (dole meaning a hollow), also called dolina or dolinen, is a sink-hole, dissolved in limestone, sometimes funnel-shaped, whose depth may reach 100m and its width 1 km in diameter. Some dolines communicate, in depth, with subterranean rivers. They are typical of karst areas. The sinks are sometimes designated as karst-holes. A sink-pocked karst expanse is commonly a limestone plateau underlain by grottoes, caverns and drained by an underground hydrographic network. A karst region is usually dry and nearly barren. The karst landscape is typical of the Adriatic Sea coast.

### CROATIA (HRVATSKA)

The Croatian coastal plain is merely a very narrow karstic strip dominated by the Dinaric Alps (Dinara Planina) [Planina=plateau, tablelands] and the Velebit Mountains. The term Dalmatia (Dalmacija) applied originally to an Austro-Hungarian Crownland but is now commonly used to designate the Adriatic coast of former Yugoslavia. All along the Dalmatian littoral, usually at a very small distance offshore, occasionally linked to the mainland (tombole), more than 600 coastal islands—making up the Dalmatian Archipelago—line the coast. Some 60 are

inhabited, including Hvar, Brač, Vis and Korčula; most are part of the contemporary Republic of Croatia. The area has been nicknamed "the coast of a thousand islands". On the border with Slovenia, the Mali Kvarner (Quarnerolo) is considered by some to be a gulf, by others a channel, while still others label it narrows. It is the area of the Croatian primorje with tourism geared islands, some small such as Rab and Pag, others larger such as Cres and Krk (Kerk). The Dalmatian littoral is very cut-up, includes a succession of bays and flat areas, a.o. the delta of the Neretna. The Dinaric Alps are part of the Alps Mountain system of central Europe. They start near Trieste and prolong into Albania. Their culminating summit is the Voljnac Point at 2600m.

The Croatian coastal zone stretches from the fortified seaport of Pula (Pola, Pulj) [prior to WW II in the Italian province of Venezia Giulia] located at the southern tip of Istria (Slovenia) to the Gulf of Kotor (Cattaro) (Montenegro). Several important ports, formerly Italian or Austrian, are located at the head of bays: Rijeka (Fiume), Pula (Pola), Zadar (Zara), Dubrovnik (Ragusa), Split (Spalato).

### SLOVENIA (SLOVENIJA)

Of the former Yugoslavian coastal region, Slovenia constitutes the Primorje, which translates into "the littoral". The Slovenian coastline lies on the Istrian Peninsula, on the Northeastern coast of the Adriatic Sea. It extends some 100km from the Gulf of Trieste to the Gulf of [Velicki] Kvarner, also known as the Kvarner Narrows (Mali Kvarner, Velicki Kvarner). Trieste (Triest, Trst, Tergeste) is a major seaport that knew Austrian, French and Italian rule on the most western limit of the Istrian Peninsula. It was for a short period (1945-1953) a Free Territory.

Istria was a major part of the karst region of Yugoslavia and considered one of its natural regions. The name of "the Karst" became used by extension for the karstic regions in Croatia and Montenegro. The relief is cut by subterranean waters, and is dotted by numerous depressions: it is a region of dolinen (cf. Croatia), and poljes--a type of closed depressions (cf. Croatia)--grottoes, springs, lakes and marshes.

Slovenia is thus at the head of the Adriatic (sometimes called Gulf of Venice). The Adriatic has very small tides (maximum normally 50cm) and is virtually all continental shelf.

### BOSNIA-HERZEGOVINA (BOSNA-HERCEGOVINA)

The country is, from a physical geography viewpoint, part of the Dinaric System (cf. Croatia), a region of karst (cf. Croatia) and poljes (cf. Croatia). The hydrographic system is dominated by two rivers, the Neretna and the Savo, and their affluents. The Dinaric Alps are part of the karst region, limestone chains. Here they place between the Slovenian Alps and the Rhodope Basin. The poljes dominate the very narrow Adriatic littoral zone. The mountainous system continues into Montenegro and Albania.

### MONTENEGRO (CNRA GORA)

The name means Black Mountain, and indeed the small country is a mountainous well forested region. Montenegro is the terminal of the North Albanian Alps. It is bounded on the northwest by Dalmatia (cf. Croatia) and the Adriatic Sea. Its coastline is approximately 48km long and includes the splendid Gulf of Kotor (Boca Kotorska), site prior to WW I of an Austrian-Hungarian naval base. The coastline is cut up by many

bays (Tivat, Risan, Kotor) linked by natural channels. The ascent from coast to the upland (e.g. Mounts Lorcen and Orijen) is particularly steep.

### EROSION AND SEA-LEVEL RISE

What would occur if the heralded sea-level rise would indeed occur? How would it affect the area, set aside its economy? Sea-level measurements taken at four points between 1965 and 2005 showed sea-level trends varying from a rise between +0.53 and +0.96 mm/y to a decrease between -0.50 and -0.82 mm/y, mainly due to local tectonic activity. Coastal areas, taking into account hypothetical 20- and 86-cm sea-level rises, show a low vulnerability. Nevertheless besides damage to historical centers, the alluvial plain of the Neretva River, and the island of Cres would be seriously endangered. Recent literature stresses that long-term national adaptation strategies to sea-level rise and



Figure 1. Location diagram showing the Dalmation Coast.

plans of actions need to be adopted, and monitoring of the shoreline evolution is necessary though impeded by its great length. The effects of assumed 20- and 86-cm sea-level rises on the coastal area were assessed by expert judgment. Coastal areas along the former Yugoslavia Adriatic shore appear to have, generally, a low vulnerability to changes in sea level. Nevertheless, consequences for tourism of a sea-level rise should not be underestimated; some important sites—think of Dubrovnik—such as historical town centres, the alluvial plain of the Neretva River, and Vrana Lake on the island of Cres would be undoubtedly threatened. It is utopic to propose, particularly for Croatia, a scheme that would protect the littoral in its entirety, principally due to its length and its already mentioned

morcellement.. Therefore, long-term national adaptation strategies to sea-level rise and plans of actions should be prepared and adopted, and monitoring of the consequences of sea-level rise and further research are required.

The coastal waters along the Eastern Adriatic were shallow during the Mesozoic: from the Triassic through the Cretassic permeable deposits of limestone accumulated, though on the Adriatic platform flysch and limestone mixed during the Palaeocene . Climatic changes have played a significant part in geomorphological shaping: during Würm sea-level was on the average 120m below the contemporary level and during the Upper Pleistocene [Würm III] several "coastal rivers" deepened their bed, and profound canyons were thus dug. During the Flandrian Transgression sea-level rose fast, but that rate eventually slowed down closer to the present. This rise accounts for the not uncommon offshore underwater springs. Except for the Neretva River that has an alluvial plain and a delta-type estuary, coastal rivers reach the Adriatic through a canyon. Three geo-tectonic zones are generally recognized in recent literature. Tectonic activity may account for contemporary rather modest local sea-level variations.

A sea-level rise would impact several economy sectors ranging from tourism to agriculture and researchers at the Split based Institute of Oceanography and Fisheries have rung an alert bell. Various remedies have been considered, though none has been officialized and one may perhaps speak of unpreparedness or of overly cautious attentisme. Aside from the onerous removal further inland of the entire coastal infrastructure like what has taken place in some sites on the Eastern United States coast and is being considered in areas of France's Atlantic coast, some have suggested, to remedy East Adriatic coastal erosion and flooding problems, hard coastal defenses be built, but the domino effect seems to have been overlooked: beaches would then be subject to sand starvation and artificial nourishment would be necessary, not excluding the extreme solution of establishing man-made beaches within tourist complexes—a costly and constant maintenance-requiring pis-aller, not unfrequently unappreciated by client and ecologist alike. Besides the tourism worries, the Neretva agricultural alluvial plain scheme now protected by dikes, water pumping and polder-like dispositions would be exposed to flood and intrusion risks. Important protective works would be necessary, similar to those in The Netherlands.

Ten years ago Croatia indicated in its statistical report that tourism in the country was entirely biased towards the coastal areas: some 95% of tourists' overnights took place on the Dalmatian coast. Hence HOREBA economics would harshly suffer from a sea-level rise, concomitant floods, shore erosion, beach shrinking, and salt intrusion, and so would the pleasure craft business and ipso facto severely impact the national economy . Of the only two existing freshwater coastal lakes, both might be affected by saltwater intrusion with the greater probability for the Biograd located one.

There is, in Dalmatia a large disparity between population and economic potential, which combined with an unusually long coastline, creates difficulties in strategic coastal defense planning, and yet planning protective measures in view of a potential sea-level rise is not forcefully pursued , though a report was published nearly fifteen years ago. Klein and Nicholls (1998) list as strategies: retreat (cf. USA, France, Belgium, Netherlands), accommodation (but to what extent?), protection (hard or soft approach ?). However, each of these approaches has its counter-indications and ecology, culture, historical patrimony, economy, and then some, has to be weighed against each other to reach a

hard to assess overall plan. This of course is not a situation proper to the Trieste to Kotor region only.

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Figure 2. Gulf or "Fjord" of Kotor, Montenegro



Figure 3. Karst relief at the littoral, Croatia



Figure 4. Tombolo, Croatia

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