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The Istria yo-yo - evidence for millennial seismic cycle in the northern Adriatic

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The Istria Peninsula in the northern Adriatic Sea (Croatia and Slovenia) is considered to be a nearly aseismic part of the Adriatic microplate, as opposed to the seismically active frontal ranges of the highly active Dinaric orogen. New archaeoseismological data from the Medieval Eufrasius cathedral in Poreč on the west coast of Istria demonstrate two, previously unknown major earthquakes, which occured approx. a millennium apart. Evidence for slow coastal uplift alternating with rapid subsidence allows to identify the seismic cycle.

A marine notch, otherwise an excellent marker of sea level, extends along a 240 km segment of the northern Adriatic rocky coast, from Trieste to Zadar. We interpret the following history of vertical displacements:

(1) Slow uplift, evidenced by the 1-2 m high, roofed marine notch oversized with respect to the microtidal regime of the Adriatic Sea. 0.5-1 m deep notches were etched into the coast between ∼3000 BC until the 4-6th century AD (Faivre et al., 2010).
(2) Rapid submergence of the notch to 1-2 m depth below sea level, dated by the construction of successive cathedrals of Poreč built on increasingly higher ground at the seaside (4-6th century AD); submergence of Cissa town on Pag island in 361 AD.
(3) Slow uplift of less than 2 m between the construction of the last, Eufrasius cathedral in the 4-6th century AD and the ∼1440 AD earthquake. No conspicuous notch were etched in the rocky shore during this period.
(4) Rapid submergence of terrestrial sediments below sea level after 1400 AD (Faivre et al., 2011). Major earthquake damage in Poreč cathedral just before 1440 AD.
(5) Slow uplift after 1440 AD, corroborated by three decades of high-precision levelling and recent GPS data (Rezo et al., 2010). No conspicuous notch etched in the rocky shore during this period.
(6) Next major earthquake with subsidence on land and uplift in the sea with tsunami... when?

In our interpretation of the seismic cycle, Istria is slowly raised, about 1-2 m in a millennium, during stress accumulation caused by a locked fault plane. Stress release produces sudden subsidence of the coast, which is recorded by subsided coastal features (marine notch, terrestrial sediments, cathedral of Poreč).

We speculate that the thrust fault responsible for the earthquakes lies below the 2-5 km thick Triassic-Cretaceous carbonate platform sequence. The fault plane is assumed to be a gently sloping surface descending towards the east within the Permian-Lower Triassic clastic and evaporite beds. Over the centuries betweeen earthquakes the fault remained locked and the gradually increasing strain was manifested by the uplift (bulging) of the west coast of Istria, whereas the offshore portion of the hanging wall probably bowed downward above the fault. When rupture occurred, the bulge suddenly lowered back to the 'original' elevation. Meanwhile, the bowed, submarine portion of Istria relaxed and possibly triggered a tsunami. Continuing NNW-ward motion of the Adriatic microplate towards Eurasia, well-documented by GPS measurements, provides energy for stress accumulation of the next earthquake cycle.

These observations challenge the current notion of Istria as the region of low seismic hazard and invite further paleoseismological research (M.K. OTKA K67.583; M.V. ARRS L1-5452 grant. B.S. contributed as Alexander von Humboldt Research Fellow)
References: Faivre et al. (2010): GeoActa, SP 3, 125-134; Faivre et al. (2011): Quat. Int. 232, 132-143; Rezo et al. (2010): EJGE 15, 1835-1847