

Electro-Corrosion of Rocks before Major Earthquakes: Ground-to-Water Interface Reactions Affects the Water Chemistry

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Attempts to identify earthquake precursors on the basis of geochemical observations began in the late 1960s. Since then numerous reports indicate that changes in the water chemistry do occur prior to major seismic events. The changes are widely believed to arise from mechanical processes such as the opening and closing of fractures, which allow circulating groundwater to gain access to fresh mineral surfaces. A very different process has been suggested to play a role in changing the water chemistry: electrochemical corrosion of rocks caused by stress-activated positive hole currents crossing the rock-water interface.

There is growing evidence that positive holes, h^{\bullet} , exist in minerals of igneous and high-grade metamorphic rocks, albeit in a dormant, electrically inactive state [1]. Those h^{\bullet} are electronic charge carriers associated with defect electrons in the oxygen anion sublattice of the minerals, equivalent to O^{-} in a matrix of O^{2-} . When mechanical stresses are applied, h^{\bullet} are activated. Those h^{\bullet} have the remarkable ability to spread out of a stressed rock volume and to travel long distances through unstressed rocks.

When the h^{\bullet} arrive at a rock-water interface, they act as highly oxidizing $\bullet O$ radicals, ripping off an H from H_2O and forming $\bullet OH$ radicals. Two $\bullet OH$ combine to H_2O_2 [2]. At the same time the rock surface becomes hydroxylated, turning into a hydrous gel. This is equivalent to accelerated weathering, a form of electrocorrosion of the rocks. In the process cations are released.

Stress-activated electrocorrosion of rocks has been demonstrated in the laboratory [2]. It seems to be an active process in the field, leading to distinct changes in the water chemistry prior to earthquakes [3,4].

References

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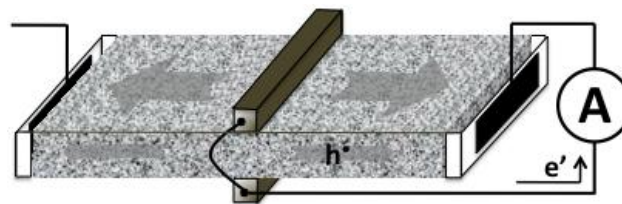


Figure 1: Experimental set-up to demonstrate the accelerated dissolution (electrocorrosion) of the rock surface while h' charge carriers flow into the water reservoir on the right for which circuit closure has been established. The identical left-side reservoir was left electrically disconnected during the entire length of the experiment [2].

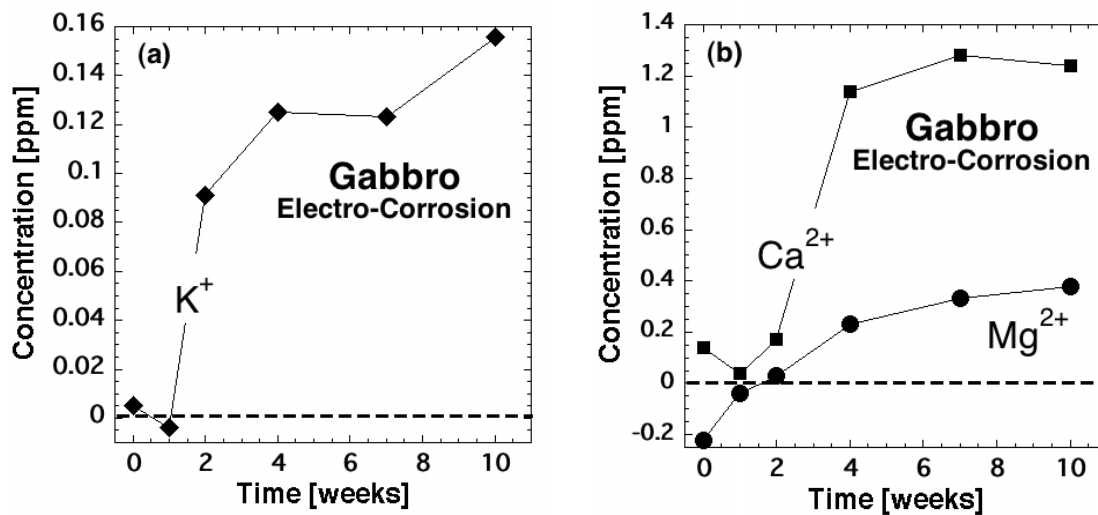


Figure 2a/b: Excess cation concentrations measured in the right side water reservoir attached to the slab of gabbro into which h' were allowed to flow continuously over a period of 10 weeks [2]. The excess concentrations were obtained by subtracting the changes in the cation contents measured in the left-side (electrically not connected) water reservoir from the changes in the cation contents in the right-side (electrically connected) water reservoir [2].

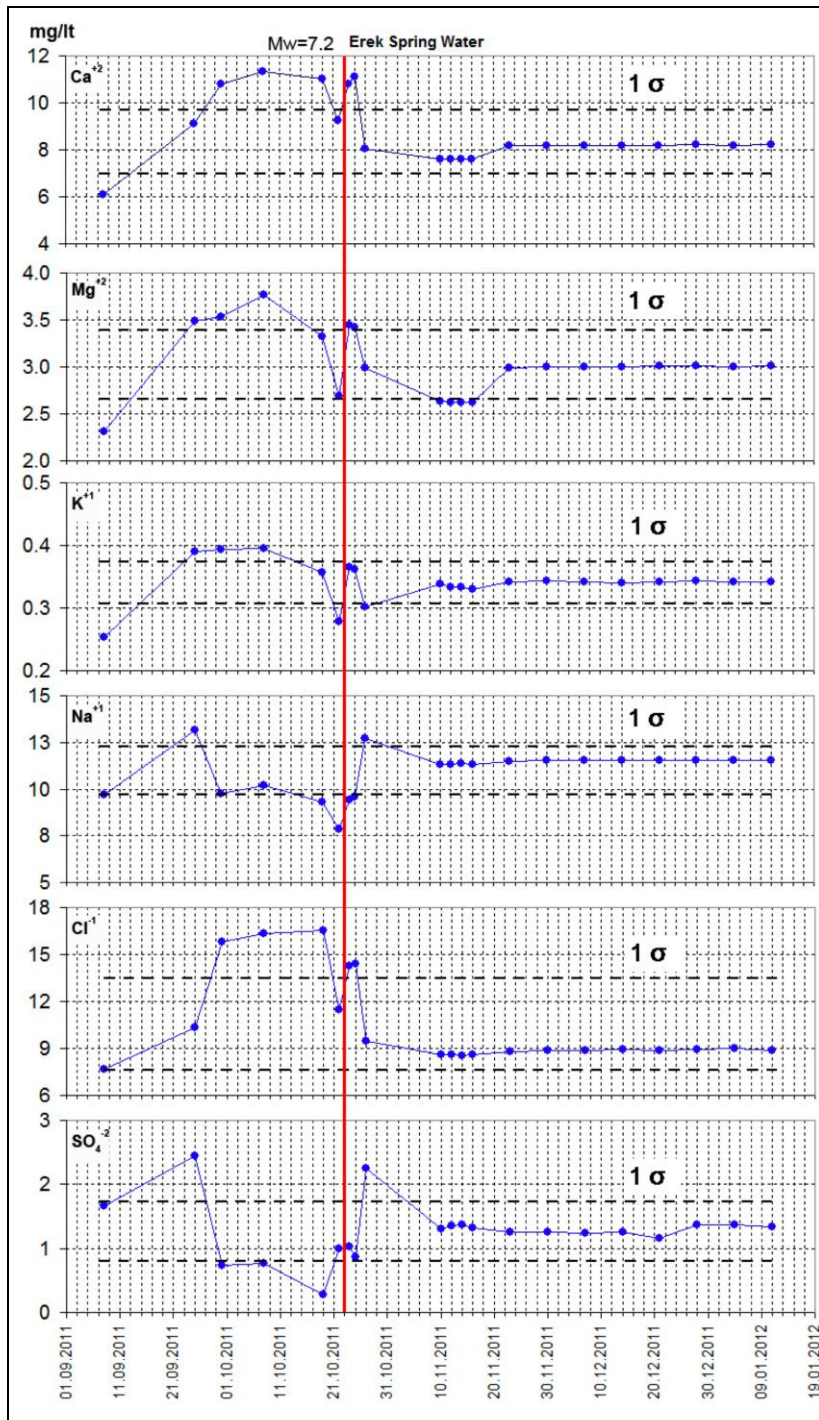


Figure 3:
 Water chemistry changes before and after the Oct. 23, 2011 M7.2 Van earthquake in East Turkey.
 Time variations of Ca²⁺, Mg²⁺, K⁺, Na⁺, Cl⁻ and SO₄²⁻ contents (mg/L) of EREK bottled waters. The day of the earthquake is marked by vertical red line. Standard deviation taking into account all data points is shown as ±1 standard deviation (1σ). Positive anomalies, i.e. increase for Ca²⁺, Mg²⁺, K⁺, Cl⁻. Negative anomalies, i.e. decrease for Na⁺, SO₄²⁻ exceeding 1σ prior to the earthquake [4].

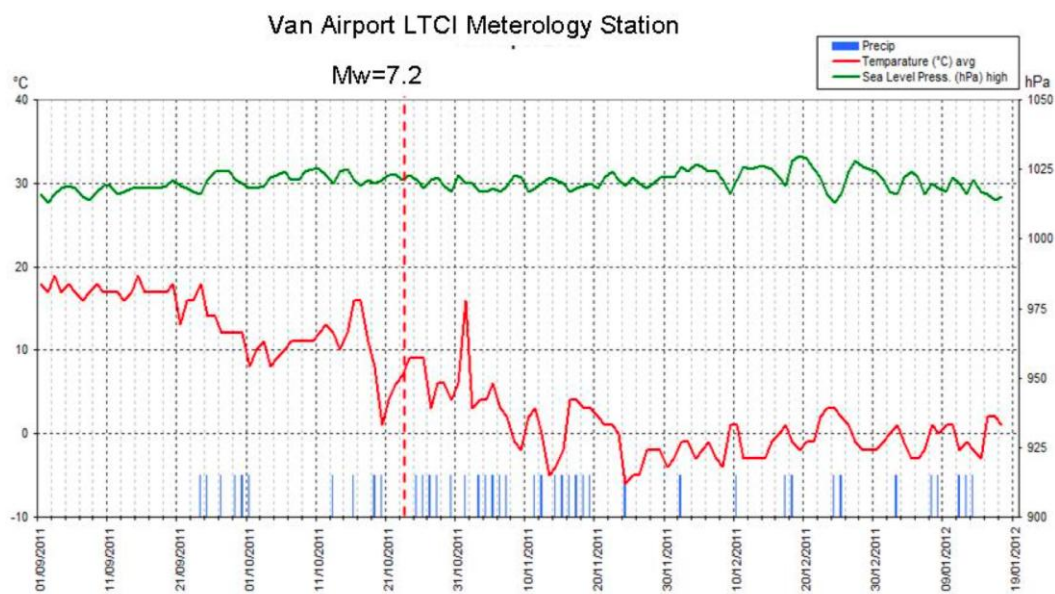


Figure 4: Meteorological parameters (daily air pressure, temperature, precipitation) obtained from the Van airport meteorological station (www.weatherunderground.com). The day of the earthquake is marked by a red dotted line. Rainy days (precipitation days) are marked by vertical blue lines [4].