MONITORING WEATHERING AND EROSION OF BEDROCK ON A COASTAL CLIFF, LONGYEARBYEN, SVALBARD

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A rockwall constituted of sandstone and shale has been monitored on an all year-around basis since the summer 2001 in order to better understand the relationship between rock temperature, rock moisture content, weathering evolution and rock fall occurrence in a high latitude environment (Longyearbyen, 78°13'N). This rockwall is located along the Adventfjorden coastline; its base was sea-washed until the road leading to Longyearbyen Airport was built in 1984.

The rockwall temperature is monitored at depths of 40 cm, 10 cm, 1 cm and at the rock surface. The rockwall is experiencing numerous and sometimes considerable temperature fluctuations, even during the polar winter, and even under a thick snow layer. Nevertheless, surface temperature crosses the zero degree threshold only in the fall and in the spring; it gets very close to zero degree several times during the polar winter, due to milder weather conditions. The amplitude of temperature variations decreases from the surface downwards due to thermal flow dampening. Even daily temperature fluctuations reach 40 cm deep, but very attenuated, and with a delay of several hours. At 40 cm deep, the rock freezes once in the fall and remains frozen. No evidence of a widespread occurrence of thermal shocks is found; this denies their efficiency as active weathering agents at the study site.

Rock moisture content is monitored by daily weighing exposed rock tablets. All samples show simultaneous fluctuations of more or less same amplitude. Rock moisture content shows large and quick variations linked to weather conditions during the fall and spring. Winter is characterized by a progressive drying of the rock, probably because of sublimation in cold arid climate. Rocks rarely reach high saturation values, and when it is the case, this happens in the fall and in the spring.

Therefore, conditions favorable to cryogenic weathering (i.e. freezing of the rock when its moisture content is high) are met only rarely. But when these conditions are met, frost action can be very aggressive, because of the high rock moisture content, the quick cooling or the extended duration of freezing periods.

A regular evaluation of rock weathering (before cracking, weight loss or any other visible change) is assessed for rock pieces exposed to the natural environment using as a criteria their dynamic Young's modulus variations. These measurements are aimed at evaluating how long an exposure to the Svalbard environment has to be for the weathering process to be initiated and how fast this decay will progress. A non-destructive determination of Young's modulus is carried out using a Grindosonic apparatus.

The aggressivity of the environment on the weathering point of view is proven by the decrease in Young's modulus of 4 out of 5 porous limestones tablets after 5 months of exposure (Sept. 2001- January 2002) at the study site. A similar exposure did not cause any decrease in the Young's modulus of 5 samples of the local sandstone. Frost action does not act through the porous media of this poorly porous sandstone, but by wedging of its wide opened and well-developed crack system. Cryogenic weathering is thought to act on this rockwall by

wedging; the dilation of rockwall cracks is automatically monitored every hour by crack extensometers.

Chemical processes are more and more considered as likely to play a role in cold environment weathering. There is locally some evidence of such weathering on the studied rockwall. This chemical weathering appears under two distinct forms, both occurring locally and with a variable intensity on the rock surface. First, iron oxidation can color the rock surface in a reddish, dark-brown color and disintegrate the iron carbonate nodules in fine materials, leaving small circular depressions on the clay-ironstone lenses. Secondly, salt outbursts can develop during dry summer periods and cover some rock beds. The salt source is the sedimentary rock itself, and not the seawater nearby. Although it is not clear whether these salts precipitation have rather a physical or a chemical weathering effect, as salt weathering can act both ways, it leads clearly to a local rock surface induration and / or desquamation. The described processes contribute to the so-called "granular weathering", i.e. they lead to the formation of very fine debris constituting the fine fraction of the talus slope.

Rock fall activity is evaluated using sediment traps and checking the decay evolution of painted squares on the rockwall. Five sediment traps are set at the base of the rockwall and collect the falling rock debris. These traps are 1.25 to 3.50 meters long and collected debris coming from rockwall portion estimated to be between 31 and 88 m^2 in surface. They are emptied about 4 times a week and the collected debris are sieved at 2 mm, dried and weight. Rock fall occurrence shows a very irregular distribution, with maximums in autumn and spring. The largest rock fall events happened on days when cryogenic weathering conditions were met.