Water origin and quality of rock glacier springs. Case studies in the Swiss Alps.

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In the current context of climate warming, rock glaciers represent potentially important water resources due to the melting of ice they contain and/or their role as high mountain aquifers. However, little is still known about the hydrological role of rock glaciers in periglacial watersheds. For this reason, this study aimed at improving knowledge about the origin and quality of rock glacier springs in order to evaluate their contribution and impact on aquatic systems. A conceptual model was developed to explain the hydro-chemical processes taking place in active rock glaciers in the current context of air, ground and permafrost temperature warming. This conceptual model is based on physico-chemical and isotopic analyses performed on water emerging from six rock glacier (of different degree of activity) in the Swiss Alps during the warm season. Similar chemical and isotopic analyses were also performed in springs located in the same catchements but fed by other water supplies. The ion content (SO_4^{2-}, Ca^{2+}, Mg^{2+} and NO_3^-) of the water emerging from rock glaciers was signficantly higher than that of sources not fed by rock glaciers. Besides, ion (SO_4^{2-}, Ca^{2+} and Mg^{2+}) and isotopic ($\delta^{18}O$) values of rock glacier springs increased significantly during the warm season. Inter-site comparison showed that these differences were more pronounced in the water emerging from active rock glaciers. In addition, a seasonal increase in electrical conductivity was also observed in these springs. We assume that the seasonal rise in physico-chemical parameters (especially electrical conductivity, SO_4^{2-}, Ca^{2+} and Mg^{2+}) could trace the increase of ground ice melting in active rock glacier outflows from the summer to the autumn. We suggest that the cryosphere stocked chemical compounds arising from atmospheric fallout during a colder period in the recent past (1960s-1980s) and that the current ground ice melting partially releases these compounds in the Alpine water systems.