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Hydrogeological characterization and 3D numerical modelling of the groundwater flow in an alpine area (Isola, San Giacomo Valley,Italy)

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The study presents the steps followed to define the hydrogeological model of an alpine slope and the simulation of groundwater flow, developed by a three-dimensional finite element numerical code (FRAC3Dvs). The geological, geomorphological and hydrogeological context of the study area, although quite complex, is well representative of an alpine environment. The case considers an area of about 4 km2 located in the Italian Central Alps, along the S. Giacomo Valley, by the side of the artificial lake created by the Isola dam on the Liro Torrent. The valley follows an almost N-S-striking tectonic lineament and also the investigated slope is affected by N-S directed structural elements, parallel to the main geomorphological feature, the Andossi high plain. The local geological setting is related to the Pennidic nappe arrangement, gently dipping to the E-NE. The crystalline basement of the Tambò unit (Upper Corbet zone), cropping out at the toe of the slope and mainly constitute by gneiss, is overlapped by a porphiritic and carbonatic meta-sediments cover (Sluga Syncline), followed by the Suretta Unit. The recent travertine deposits and carniola lenses in the meta-sedimentary succession, represent important hydrogeological indicators testifying the abundant water circulation that characterizes the area. The geological and geomorphological surveys have been performed, together with the definition of the hydrographic features, and the relative maps (scale 1:5000) have been produced. Detailed geomechanical surveys, carried out according to the ISRM suggested methods, both on outcropping rock masses and in underground (down to a depth of -150 m), have provided the quantitative characterization of the rock mass fracturing state. The entity, persistency, aperture and roughness of the discontinuities suggest a general superficial ground water flow, with some exceptions where the high connectivity of the fracture system is favourable

to locally increase the rock mass hydraulic conductivity. The analysis of the spring hydrochemical properties and their discharge have supplied additional information in defining the hypothesis of groundwater flow. The low concentration of the dissolved minerals together with the low average discharge (few l/s) have confirmed the presence of a low-depth water circolation and the short resident time of water in rock masses. The performed study have provided the data necessary to define the hydrogeological conceptual model used for the successive phase of numerical modeling. The three-dimensional finite element code FRAC3Dvs has been used to analyze the groundwater flow. The rock mass hydraulic conductivities have been evaluated trough the percolation theory according to the Baecker model assuming disc-shaped discontinuities. The model calibration in steady state conditions has been carried out considering the many springs emerging along the slope. Position and measured base discharge of each spring has been assumed, in the calibration process, as independent variables, while hydraulic conductivity of the rock masses and uphill groundwater recharge as dependant variables. The calibrated model has been then used to perform transient analysis varying the condition of recharge as a function of the total amount of precipitation. The model represents a useful tool to evaluate the groundwater discharge into the artificial lake and the spring water availability under different recharge conditions. These data are very helpful to explore the groundwater resources of the area both in term of potential water supply and of safe management of the artificial reservoir.