



**HAL**  
open science

## Computing the drainage discharge and assessing the impacts of tunnels drilled in Hard Rocks

Patrick Lachassagne, Jean-Christophe Maréchal, Claudine Lamotte, J.-C Maréchal, Patrick Bienfait, Frédéric Lacquement, Claudine Lamotte

► **To cite this version:**

Patrick Lachassagne, Jean-Christophe Maréchal, Claudine Lamotte, J.-C Maréchal, Patrick Bienfait, et al.. Computing the drainage discharge and assessing the impacts of tunnels drilled in Hard Rocks. Engineering Geology for Society and Territory, 3, Springer International Publishing, pp.595-599, 2015. hal-02272180

**HAL Id: hal-02272180**

**<https://brgm.hal.science/hal-02272180v1>**

Submitted on 27 Aug 2019

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

## Computing the drainage discharge and assessing the impacts of tunnels drilled in Hard Rocks

LACHASSAGNE P.<sup>1</sup>, J.-C. MARECHAL<sup>2</sup>, P. BIENFAIT<sup>3</sup>, F. LACQUEMENT<sup>4</sup>, Cl. LAMOTTE<sup>5</sup>

<sup>1</sup> EVWS - Danone Waters France - 11, av. du Général Dupas - BP 87 - 74503 Evian-Les-Bains Cedex, France

<sup>2</sup> BRGM – Direction D3E, Eau, Environnement et Ecotechnologies, 1039, rue de Pinville, 34000 MONTPELLIER, France

<sup>3</sup> EGIS - Egis Tunnels - Les Pléiades N°35 - 74373 Pringy cedex

<sup>4</sup> BRGM – Direction des Géoressources, 3 av. Claude Guillemin, 45060 ORLEANS Cedex

<sup>5</sup> BRGM – Direction régionale Languedoc-Roussillon, 1039, rue de Pinville, 34000 MONTPELLIER, France

Contact: P. Lachassagne ([patrick.lachassagne@danone.com](mailto:patrick.lachassagne@danone.com))

### Abstract:

Most Hard Rocks (HR) are or were exposed to deep weathering processes. It turns out that the hydraulic conductivity of HR is mostly inherited from these weathering processes (Lachassagne *et al.*, 2011):

- (i) within their permeable Stratiform Fissured Layer (SFL) located below the low hydraulic conductivity unconsolidated weathered layer (saprolite). The thickness of both layers often reaches more than 100 m (Dewandel *et al.*, 2006),
- (ii) and within the permeable vertical fissured layer developed at the periphery of or within preexisting geological discontinuities (joints, dykes, veins, lithological discontinuities, etc.) (Dewandel *et al.*, 2011, Roques *et al.*, 2012).

From this conceptual model, the drainage discharge and the surface hydrogeological (piezometry in wells) and hydrological (discharge of streams) impacts of shallow highway tunnels drilled in a metamorphic series (metasedimentary and metavolcanic rocks) intruded by granitic bodies have been forecasted. These tunnels belong to the A89 highway recently opened (2012) in France between Balbigny and La Tour de Salvagny (Monts du Lyonnais, 50 km West of Lyon city). They are up to 4 km long, and their depth below ground level ranges between 0 and 300 m. The method is based on:

1. the location of the tunnel within or below the various layers constituting the weathering profile. Four different weathering profiles with ages from Triassic to post Miocene were identified, and mapped (extension, thickness). Their relative effects (fissuration) in the various lithologies of the area have been identified (Fig. 1);
2. steady state groundwater discharge measurements in existing tunnels (railway) of the area where weathering profiles were similarly mapped;
3. application of the Goodman *et al.* (1965) analytical solution that allowed (i) to inverse steady state railway tunnels groundwater discharge into the hydraulic conductivity of the various layers of the weathering profiles, and (ii) to compute the discharge of the future highway tunnels, on the basis of the hydraulic conductivity of the weathering profiles that these highway tunnels crosscut.

The actual discharge of the now completed highway tunnels (Fig. 2) validates the accuracy of the methodology. For instance, the forecasted discharge of the main 4 km long Violay tunnel was between 4 and 7 l/s and was finally about 6 l/s in the tunnel. The hydrological impact on surface water (low stage stream discharge) was also forecasted for each surface watershed intersected by the tunnels (Fig. 2, Gantet watershed, in red). This method proves to be very efficient for shallow tunnels in hard rock areas.

### References:

Dewandel B., Lachassagne P., Chandra S., Zaidi F. K. (2011). "Conceptual Hydrodynamic model of a geological discontinuity in hard rock aquifers: example of quartz reef in granitic terrain in South India." *Journal of*

Hydrology, 405, 474–487.

Dewandel B., Lachassagne P., Wyns R., Maréchal J. C., Krishnamurthy N. S. (2006). "A generalized 3-D geological and hydrogeological conceptual model of granite aquifers controlled by single or multiphase weathering." *Journal of Hydrology* 330(1-2): 260-284.

Goodman, R.E., Moye, D.G., Van Schalkwyk, A. and Javandel, I., 1965. Ground water inflows during tunnel driving. *Engineering Geology*, 2(1): 39-56.

Lachassagne P., Wyns R., Dewandel B. (2011). "The fracture permeability of hard rock aquifers is due neither to tectonics, nor to unloading, but to weathering processes". *Terra Nova*, 23, 145-161.

Roques C., Aquilina L., Bour O., Le Borgne T., Longuevergne L., Dauteuil O., Vergnaud V., Labasque Th., Lavenant N., Hochreutener R., Dewandel B., Mougin B., Schroetter J.M., Palvadeau E., Lucassou F., Jegou J.P. (2012). "Hydrogeological and geochemical characterization of a deep hard-rock aquifer (Saint-Brice, French Brittany)". *Proceedings of the Int. Conf. on groundwater in Fractured Rocks, Prague, Czech Republic, 21-24 may 2012*, p. 39.

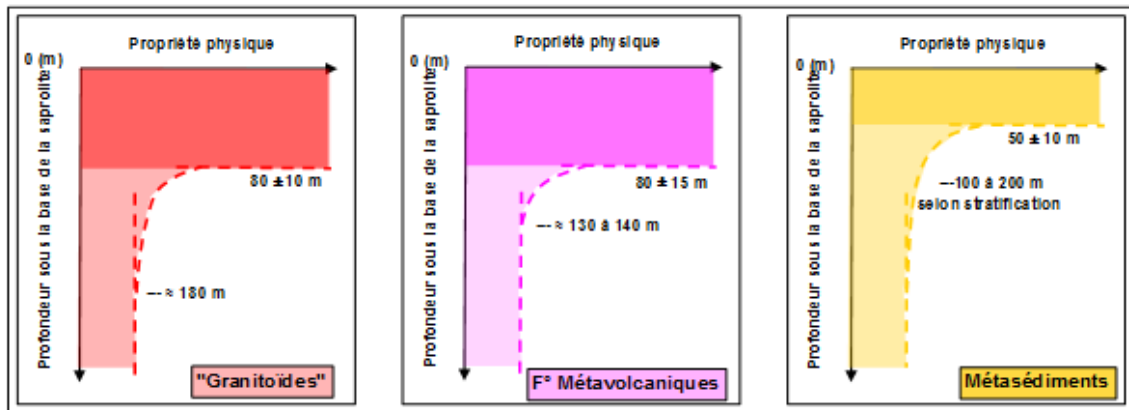


Figure 1: geometric characteristics of the phase 2 weathering profile SFL for various lithologies (Y: depth below the saprolite base, Z: modelled physical property, hydraulic conductivity for instance)

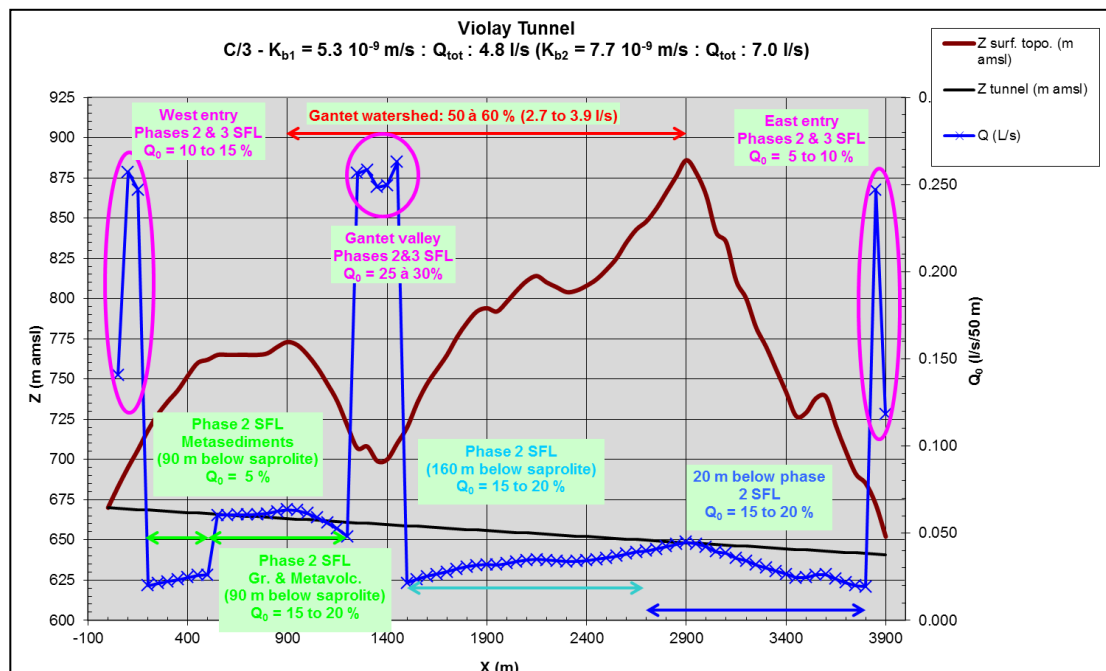


Figure 2: Violay tunnel computed discharge  $Q_0$  (blue crosses - L/s/50 m of tunnel) according to the lithology, the weathering grade and the depth of the tunnel (black line) below the topographic surface (brown profile). Red: estimated low stage discharge loss in the Gantet watershed