Validation of rock sample data: the DynVolc database

DynVolc database (2017): DYNVOLC Database. Observatoire de Physique du Globe de Clermont-Ferrand, Aubière, France. DOI:10.25519/DYNVOLC-Database (http://opgc.fr/vobs/so_interface.php?so=dynvolc) is an integrated collection of data from physical and petrological measurements of pyroclasts (bombs, blocks, lapilli and ash) and fragments of lava, sampled during on-going eruptions or past events. The database spans the full range of explosive and effusive activity types.

DynVolc database is part of the French SNO-V (Service National d'Observation en Volcanologie) and has been used as a prototype of rock analyses database within EPOS-WP11-DDSS-026_Collection of rocks, WP11-DDSS-036_Geochemical analyses of rocks, gas and fluids") and WP11.4.4_Petrological, Geochemical, and Environmental Data and Data Products). It has been used as an example in EUROVOLC (WP4 and WP6) and EVE (European Volcano Early Warning System) as well.

DynVolc database is the results of a textural and chemical monitoring effort performed during eruptive crises at **Piton de La Fournaise** (La Réunion, France), **New Volcan (Mayotte**) and other French quiescent (**Petite Terre de Mayotte, Chaîne des Puys**) or unrest (**La Soufriere de Guadeloupe**) volcanos.

For active systems, the objective of this database is to provide time series of textural, petrographic and geochemical data. These data allow us to follow the evolution of degassing, rheology, chemistry and fragmentation of magma in time and space, from the conduit to explosive manifestations at the surface (Gurioli et al. 2018; Thivet et al. 2020a, b, c) for single eruptions or eruptive cycles at larger scale (Coppola et al. 2017; Vlastelic et al. 2018). For lavas, the goal is also to obtain the temporal and spatial evolution of rheology, dynamics and flow morphology (Roberts et al. 2014; Harris et al. 2017; 2019a; b) as well as to model their emplacement mechanisms (Harris et al. 2016; Latutrie et al. 2017; Rhety et al. 2017; Soldati et al. 2018).

For quiescent systems, the goal is to define the different eruptive scenarios that could occur in the event of future reactivation.

These data are crucial for the monitoring of active volcanoes and are fundamental for the prediction of volcanic eruptions (Gurioli et al. 2015; Polacci et al. 2017).

Measurement protocols

A workshop entitled "Tracking and understanding volcanic emissions through cross-disciplinary integration: A textural working group." took place at Blaise Pascal University (Clermont-Ferrand, France) on November 6 and 7, 2012. This workshop was supported by the European Science Foundation (ESF), MeMoVolc. With an initial advisory group, the main objective of the workshop was to define the measurements, methods, formats and standards to be applied in the integration of geophysical, physical and textural data collected during volcanic eruptions and to homogenize procedures for past and ongoing events (http://www.esf.org/activities/memovolc-activities.html, Gurioli et al. 2015).

The harmonization of these data is now underway in the EPOS and EUROVOLC European projects.

Sampling strategy The first step consists of collecting representative samples both from deposits from past eruptions (Jordan et al. 2016; Colombier et al. 2017a; Prival et al. 2020) or recent deposits, for which samples are taken during the eruption (Gurioli et al. 2014; 2018; Leduc et al. 2015; Edward et al. 2020; Thivet et al 2020a; b). The samples can be collected

using sampling devices placed inside the fallout field (Harris et al. 2013; Gurioli et al. 2016; Colo 'et al. 2020) or near a lava flow (Harris et al. 2017; Chevrel et al. 2018; Harris et al 2019a), or even a few hours to a few days after the eruptive event (Gurioli et al. 2008; 2013; 2018).

Within the context of DynVolc, samples from active volcanoes (Piton de La Fournaise, Mayotte) are systematically sent by the OVPF in collaboration with A. Di Muro (OVPF-IPGP), and A Peltier (Director of the OVPF), both as solid samples (for textural measurements and microanalysis of EPMA phases; SEM) and as ground samples. P Besson at IPGP performs rapid major and trace analyses (XRF; ICP-MS) and phase characterizations (XRD). The crushed samples are then measured at the OPGC for analysis of major (ICP-AES), trace (ICP-MS), and radiogenic isotopes of Sr, Nd and Pb (ICP-MS).

Routine Measurements are fast, robust, reliable and precise thanks to the use of innovative instruments available at the LMV Textural Laboratory in combination with other high quality analytical facilities available at LMV or at Université Clermont Auvergne (Tables 1 and 2).

(http://lmv.univ-bpclermont.fr/caracterisation-texturale-des-produits-volcaniques/)

Instrumental resources	Role in the SNO	Location	Technical support
-Sieves -Scanner - Optical microscope -Software for image analysis - Geopyc 1360 -AccuPyc II 1340 -Water Pycnometer -Permeameter -Morphologi G3	Analyses de routin	Laboratoire Textural LMV	Gurioli (OPGC-LMV) Suchorski IE CNRS
-ASHER	In situ grain size, terminal velocity and accumulation rate in-situ	OVPF	Prof Marchetti M (Université de Florence)
-Two thermal camera	In situ explosion, plume and lava measurements	LMV	Prof Harris A (LMV-OPGC)
- Malvern Master-sizer 3000	Punctual analysis	Institute de Chimie Clermont Ferrand	Prof Nedelec J-M (ICCF)
-ICP-AES -Thin section preparation -Probe -Cutting and grinding samples -SEM -Clean room	Routine analyses	Technical pole at LMV	Benbakkar IE-UCA-LMV Constantin T UCA-OPGC Devidal IE UCA-OPGC Fonquernie T UCA-OPGC Voyer CNRS Vlastelic CR

Table 1 Instruments used for DynVolc.

• Grain size analyses are carried out in-situ with thermal images of the explosion (Bombrun et al. 2015) or with digital photos (Edwards et al. 2020), or directly on the deposits (Gurioli et al. 2013), using tarps (Harris et al. 2013; Gurioli et al. 2016, Colo 'et al. 2020), or with the ASHER (Marchetti et al. 2013; Gurioli et al. 2016). In the laboratory, the classical method (with the sieve) is used for the particle fraction up to 63 µm (Jordan et al. 2016; Colombier et al. 2017a; Gurioli et al. 2018; Thivet et al; 2020b), while for finer fractions we use a laser diffraction, a Malvern Mastersizer 3000 particle size analyzer (Thivet et al. 2020c).

• Componentry The larger size classes are selected by hand (Gurioli et al. 2018; Thivet et al. 2020b; c). For size classes from 2 mm to 0.5 mm, manual sampling is performed under a binocular microscope using fine forceps (Jordan et al. 2016). For the finer classes, thin sections or plots of grains of similar size, are made (Thivet et al. 2020b; c). Observation and counting are then carried out with an optical and electron microscope (SEM).

• Morphological analyses are performed in situ, during explosions explosions with thermal or digital cameras (Bombrun et al. 2015), or on coarse particles with digital photos (Bernard et al. 2014; Gurioli et al. 2016) or on the ashy part using the Malvern Morphologi® G3 (Leibrandt and Le Pennec 2015; Thivet et al. 2020b; c).

Measured quantities	Scientific meaning	Sensors/instruments
Physical characteristic of the particles (1) Particle size and distribution (2) Particle type (componentry) (3) Particle morphology	(1) Grain size analyses: - energy of the fragmentation of the explosion -genetic interpretation of pyroclastic deposits -classification of volcanic events in combination with the dispersion of deposits (2) + (3) Lithology and morphology: -mechanisms and types of fragmentation -information about the supply system and the processes active in the dyke/conduit -probability of a particle to settle or remain in suspension in the atmosphere	-ASHER -Tarps -Thermal camera -Sieves - Malvern Mastersizer 3000 -Morphologi G3 -Binocular and optical microscope -Automatic point count with optical microscope or SEM counting
Macroscopic texture (4) Density / porosity and (5) magma density (DRE) (6) Degree of connectivity of vesicles (7) Permeability	(4 and 5) Density / porosity: - gas content of the magma and its textural heterogeneity at the level of fragmentation (6) Connectivity: magma degassing capacity near fragmentation (7) Permeability: the development of permeability and degassing of the magmas	- Micromeritics Geopyc 1360 -AccuPyc II 1340 Micromeritics Gas Displacement Helium Pycnometer -Takeuchi et al. (2008) type permeameter
Microscopic texture (8) Percentage of vesicles and (9) crystals (10) size distribution of vesicles and (11) crystals (12 + 13) and their morphology	(8-13) Quantitative information on: -ascension (speed of ascent), -vesiculation / crystallinity (nucleation and increasing rate) -fragmentation of magma (type and rheology)	-Scanner -Optic microscopy -SEM - Software for image analysis -FOAMS (Fast Object Analysis and Measurement System)
Chemical analyses (14 + 15) Major elements (in total rock and glass) and (16 + 17) in trace (in bulk rock and glass) (18) crystal composition	(14-18) Quantitative information on -Classification of magma -Chemical evolution -Deep refill - Magma temperature -Rheology	-Probe -l'ICP-AES -Clean room

Table 2 DynVolc analyses list

• Density and porosity measurements are carried out with the Archimedes method for pyroclasts (Shea et al. 2010a) and lavas (Roberts et al. 2014), with the glass beads method (Colombier et al; 2017a) and with the Geopyc 1360 envelope density analyzer from Micromeritics (Thivet et al. 2020a). Water pycnometers are used to measure the density of ash (Thivet et al; 2020 c). The porosity is then calculated from the DRE (dense rock equivalent) value measured on the sample powder, which represents the density of the sample without taking into account the vesicles.

• Connectivity measurements to obtain the percentage of isolated vesicles, are made with the AccuPyc II 1340 Gas Displacement Helium Pycnometer from Micromeritics (Colombier et al. 2017a, 2017b; Gurioli et al. 2018; Thivet et al. 2020a)

• The permeability is measured with a permeameter designed by Takeuchi et al. (2008). During the visiting professor position of T Shea (University of Hawaii at Manoa) at Clermond-Ferrand in May 2013, we built the instrument that allows us to perform highly reproducible permeability

measurements using porous volcanic materials (Colombier et al. 2017a, b; Gurioli et al; 2018; Thivet et al. 2020b).

• Microscopic textural quantification involves a complete description of the size, shape and distribution of vesicles and crystals of the products emitted (Gurioli et al. 2015). DynVolc provides texture measurements based on the 2-D approach (Shea et al. 2010a, Gurioli et al. 2018; Thivet et al. 2020a; b)

• Petrological, chemical and geochemical analyses are carried out both in situ and in total rock on explosive and effusive samples. Point analyses are carried out on glasses and crystals using an electron microprobe (Roberts et al. 2014; Gurioli et al. 2015, 2018; Rose-Koga et al. 2016; Vlastelic et al. 2016, 2018; Thivet et al. 2020a; b). Bulk rock analyses are carried out using ICP-AES.

The samples are studied at the LMV by a group of experts in the field of textural (Gurioli), petrographic (E Medard and P. Bachélery), geochemical (I. Vlastélic) and remote sensing and modeling (A Harris) measurements. The measurements are carried out with the support of the LMV technical pole: C. Fonquernie for the chemical preparation of the samples, C. Constantin (preparation of thin sections), K. Suchorski (technical support for Morphology G3), E. Voyer (responsible MEB), M. Benbakkar (ICP-AES analyzes), J.-L. Devidal (electronic microprobe manager), Y Guehenneux and P Cacault for IT support at the OPGC.

Descriptions of the methodologies, sensors and machines are reported

(i) in the DynVolc webpage: http://wwwobs.univ-bpclermont.fr/SO/televolc/dynvolc/routine.php

(ii) in the EUROVOLC WP4.2 deliverable report (Gurioli et al. 2020) and deposited in https://drive.google.com/drive/folders/1UE0S6m7giqO2sqqNJO3hh6QaWY4xlRWv?usp=sharing

(iii) in the papers of the references list

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