European volcanological supersite in Iceland: a monitoring system and network for the future

Report

Rapid ESP data base and probability density functions of ESP for key volcanoes

Work Package:	*Evaluation of known eruption source parameters*	
Work Package number:	*WP4*	
Deliverable:	*Rapid ESP data base and probability density functions of ESP for key volcanoes*	
Deliverable number:	*D4.1*	
Type of Activity:	*RTD*	
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Responsible participant:	*NERC*	
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Type of Deliverable:	*Report [X]* *Prototype [ ]*	*Demonstrator [ ]* *Other [ ]*
Dissemination level:	*Public [X]* *Prog. Participants [ ]*	*Restricted Designated Group [ ]* *Confidential (consortium) [ ]*

Seventh Framework Programme
EC project number: 308377

Summary

A database of eruption source potential (ESP) is being made for key volcanoes to provide rapid access to a summary of eruptive parameters to end users. A summary report of ESP has been completed for all volcanic systems in Iceland. Detailed ESP information on individual historical eruptions (in a form of a searchable database) has been completed for Hekla and Katla volcanoes and work is ongoing for Reykjanes, Grímsvötn and Bárðarbunga (partners 1, 2 and 5).

Partner 16 has developed probability density functions (PDF) for a number of parameters for Hekla and Katla volcanoes (highest-priority volcanoes), as well as for Eyjafjallajökull and Askja volcanoes (2nd highest priority). This work was complementary to Futurevolc and the results are highly relevant for the focus of WP4. The same methodology will be used to develop further PDF for Icelandic volcanoes within WP4.

Introduction

1. Eruption source parameters database: The Catalogue of Icelandic Volcanoes (CIV, web resource, see description of Task 4.1) will include an ESP database. The Catalogue users will be able to access a summary of ESP for each volcanic system. In addition, for key volcanoes, users will be able to search and view ESP data on individual historical eruptions. The eruption data included in the search are more accurate and better referenced than those currently available through the Smithsonian GVP database, and include several additional parameters.

2. Probability density functions: The aim is to develop probability density functions for the main ESP's for selected key volcanoes. PDF's are based on data already published, as well as data compiled within the ESP database described above.

Progress and results

1. The rapid-access ESP summary database has been compiled for all Icelandic volcanic systems. It is in the form shown as an example for Katla volcano in Table 1 and can be provided to collaborators upon request. Accompanying the database are figures which show:

(i) Maps of distribution of eruptive products. Examples of lava flow and tephra distribution for an eruption in Katla volcano are shown in Figure 1.

(ii) Grain size distribution; an example from an 870 CE eruption in Bárdarbunga is shown in Figure 2. Newly analysed grain size data for several eruptions are added to the database in order to describe a full range of likely eruption scenarios in Iceland. These include tephra from Katla (K1918, K1755, Katla prehistoric silicic eruptions), the eruption at Vatnaöldur in 871 (settlement layer) and Reykjanes 1226 (Miðaldalag) have been sampled and analysed. The grain size analyses of individual samples, 10-41 samples from each tephra layer, have been performed. In addition, samples have been collected for other eruptions, including Öræfajökull 1362, Grímsvötn 2011 and Eyjafjallajökull 2010 and grain size analyses done on individual samples. In general the spatial spacing of sampling locations is not sufficient for accurate total grain size analysis but the samples should provide a reasonable estimate of the characteristics of each eruption.

(iii) Other plots of ESP data and eruption scenarios, as for example shown in Figure 3 for the Katla volcanic system.

The content of the whole database is currently being checked for consistent formatting and prepared to be published on the open-access Futurevolc web resource which constitutes deliverable D4.2.

2. PDF's have been developed for a number of parameters for Hekla and Katla volcanoes (highest-priority volcanoes), as well as for Eyjafjallajökull and Askja volcanoes (2nd highest priority). The results have been submitted for publication (Biass et al. 2014). Different eruption scenarios were considered (Figure 4). This work was complementary to Futurevolc and the results are highly relevant

for the focus of WP4. The same methodology will be applied to develop PDF for further ESP in the database. The results of Biass et al. allow assessment and comparison of hazard levels at different scales. For example, at a national scale Askja has a 5–10 % probability of blanketing the easternmost half of the country with a tephra accumulation of at least 1 kgm^{-2}. At a continental scale, Katla has a 5–10 % probability of producing ash clouds with concentrations of 2 mgm^{-3} over the UK, Scandinavia and northern Europe with a mean arrival time of 48–72 h and a mean persistence time of 6–18 h.

Reference list

Biass, S., Scaini, C., Bonadonna, C., Folch, A., Smith, K., and Höskuldsson, A.: A multi-scale risk assessment for tephra fallout and airborne concentration from multiple Icelandic volcanoes – Part 1: Hazard assessment, Nat. Hazards Earth Syst. Sci. Discuss., 2, 2463-2529, doi:10.5194/nhessd-2-2463-2014, 2014.

Table 1: Structure of ESP database for Icelandic volcanic systems

Summary for each system (example: Katla. Authors G. Larsen & M.T. Gudmundsson)

The partly ice covered Katla volcanic system has been highly active in the Holocene with at least 21 eruption in the last 1100 years. The last eruption to break through the ice took place in 1918 CE. The Katla system lies on the Eastern Volcanic Zone and is about 80 km long, consisting of a central volcano rising to 1500 m a.s.l. and an active fissure swarm extending towards northeast. The central volcano is partly covered by up to 700 m thick ice and has an 9x14 km icefilled caldera. The characteristic activity is explosive basaltic eruptions at the Katla central volcano with tephra volumes (bulk volume) ranging from 0.02 to over 2 km^3, accompanied by jökulhlaups with maximum discharge of up to 300.000 m^3/sec. The largest eruptions are effusive basaltic eruptions on the fissure swarm with lava volumes ≥18 km^3. Eruption frequency during the last 1100 years is 1 eruption per 50 years.

Summary ESP tables for each volcanic system

Lat, lon:	63°38´N, 19°05´W
Elevation:	1490 m a.s.l.
Type:	Subglacial volcano with caldera
Summit ice cover:	Yes
Dominant type of activity:	Basaltic explosive, phreatomagmatic
Magma type:	Basalt dominant, silicic infrequent
Known precursors:	Earthquakes felt 2-10 hours before subaerial outbreak
Expected precursors:	Significant increase in seismic, tectonic and geothermal activity
Monitoring level:	High
Current seismicity:	Low to moderate
Eruption characteristics:	
Type of products:	Airborne tephra, water-transported tephra, lava flows
Volcanic Explosivity Index	Max: VEI 5; most freq: VEI 3-4; min: VEI 2
Column height:	14 km (1918)
Duration of eruptions:	Days to months
Bulk volume tephra (km^3):	Max: ≥2; aver: 0.05-0.5; min: ≤0.02
Fallout beyond 1000 km:	Two in 400 years (1625 & 1755 CE)
Tephra <63µm at 30 km	Basaltic 4-25% (1755 CE), Silicic 14-30% (Holocene)
Bulk volume lava (km^3):	Max: ≈0.1; min ≈0.01
Longest lava flow:	15-20 km
Gas emissions, sulpur:	Small to significant, depending on magma volume
Interval between eruptions, years:	(last 1000 years) Max: >100; average: 55; min: 13.
Last significant eruption:	12. Oct. 1918 CE. VEI 4, airborne tephra 0.7 km^3, water-transported volcanic debris ~0.7 km^3, no lava, volcanic fissure <4 km
Seismic characteristics:	>75% at depth < 4 km, inside caldera; seasonal cluster on western flank
Deformation characteristics:	
Current activity:	<Web application only – live activity update>
Distance to international airports:	Keflavík 170 km, Reykjavík 150 km, Akureyri 230 km, Egilsstaðir 290 km.
Principal hazards:	Jökulhlaups, tephra fallout, lightnings

Detailed text describing:

1. Geological setting, magmatic and tectonic context
2. Morphology and topography
3. Plumbing system
4. Eruption history and pattern
5. Characteristics during non-eruptive periods
6. Precursory signals
7. Erupted materia
8. Hazards
9. Current activity status and monitoring (with time stamp)
10. Eruption scenarios based on last 2000 years: small, medium, large
11. Largest known eruption
12. Appraisal of extent of knowledge and bibliography

Selection of dynamic maps (e.g. Figs 1 and 2), graphs (e.g. Fig 3) and photographs

Searchable database on individual historical eruption parameters for key volcanoes

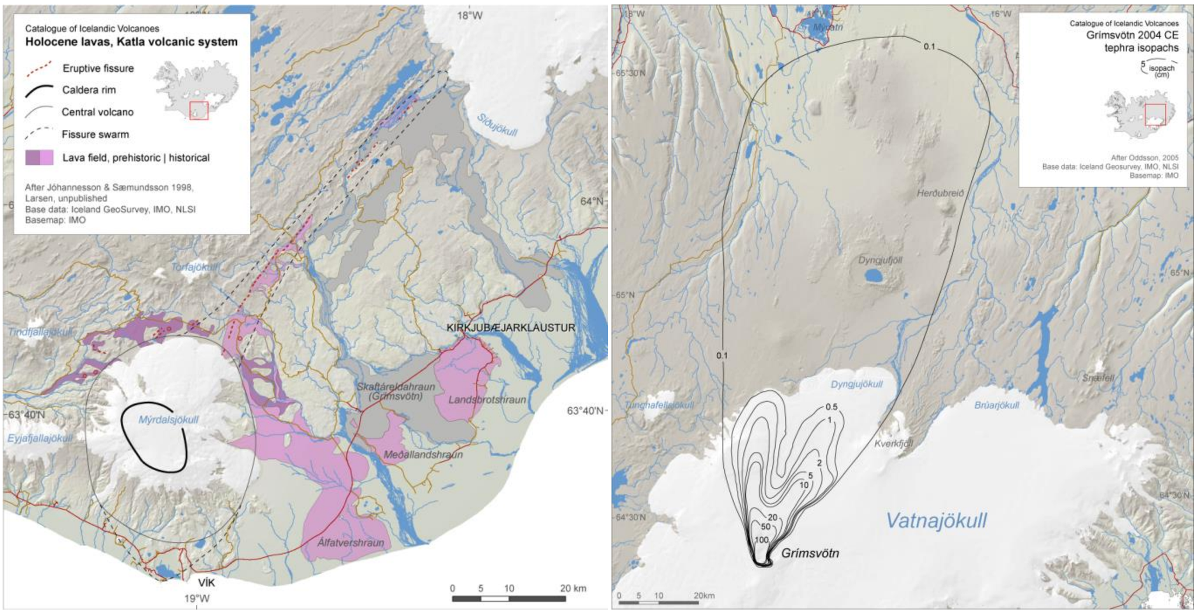

Figure 1: Examples of maps showing distribution of eruptive products, lava (left) and tephra (right). Note that the Catalogue web resource (deliverable D4.2) will also provide dynamic maps

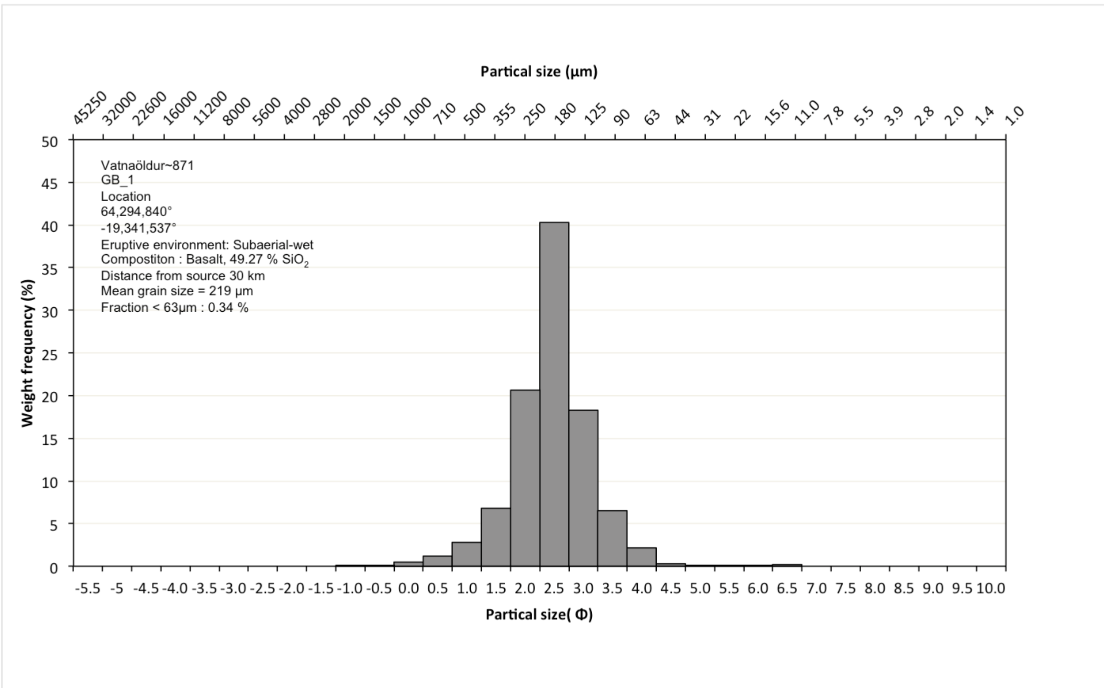

Figure 2: Example of a figure showing grain size distribution for the 870 CE eruption of Bardarbunga. Newly analysed grain size data are included in the database in order to describe a full range of likely eruption scenarios in Iceland.

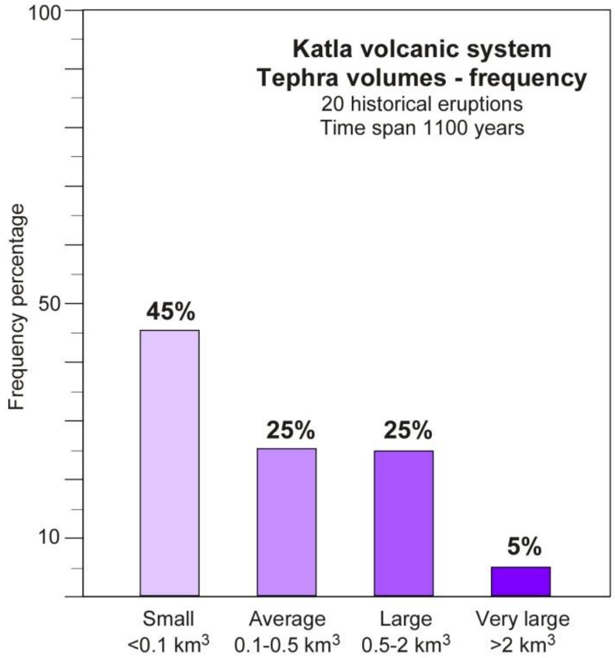

Figure 3: Example of graphical ESP data representation. The histogram shows the frequency of different eruption scenarios in Katla volcano. Based on historical activity, small eruptions are the most likely scenario.

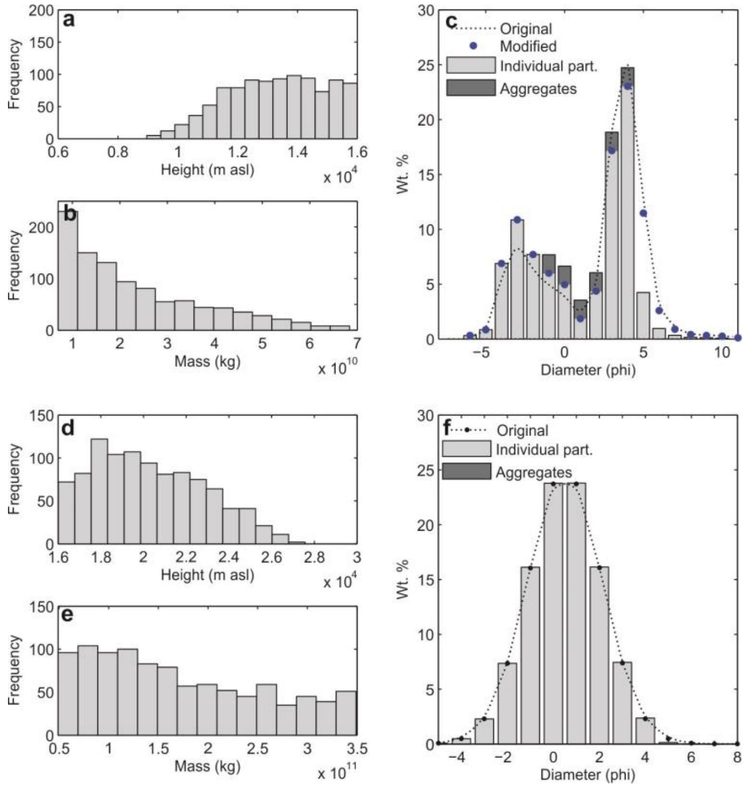

Figure 4: Example of PDF produced for different eruption scenarios of Hekla **(a–c)** Hekla 2000-scenario (small) and **(d–f)** Hekla 1947-scenario (large) a and d: plume height (m a.s.l.); b and d: erupted mass; c and f: total grainsize distribution. Histograms in c and f show both the fractions of individual particles (light grey) and aggregates (dark grey) generated, based on the algorithm explained in the text; original indicates the original grainsize distribution obtained from sieving (i.e. not containing. Figure from Biass et al. (2014),