

# Physical properties of fresh or hydrothermalized volcanic rocks from the west coast of Basse-Terre and Terre-de-Haut (Guadeloupe archipelago)



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## Project presentation

The GEOTREF project (geothermal energy in high enthalpy fractured reservoirs) tries to achieve several goals:

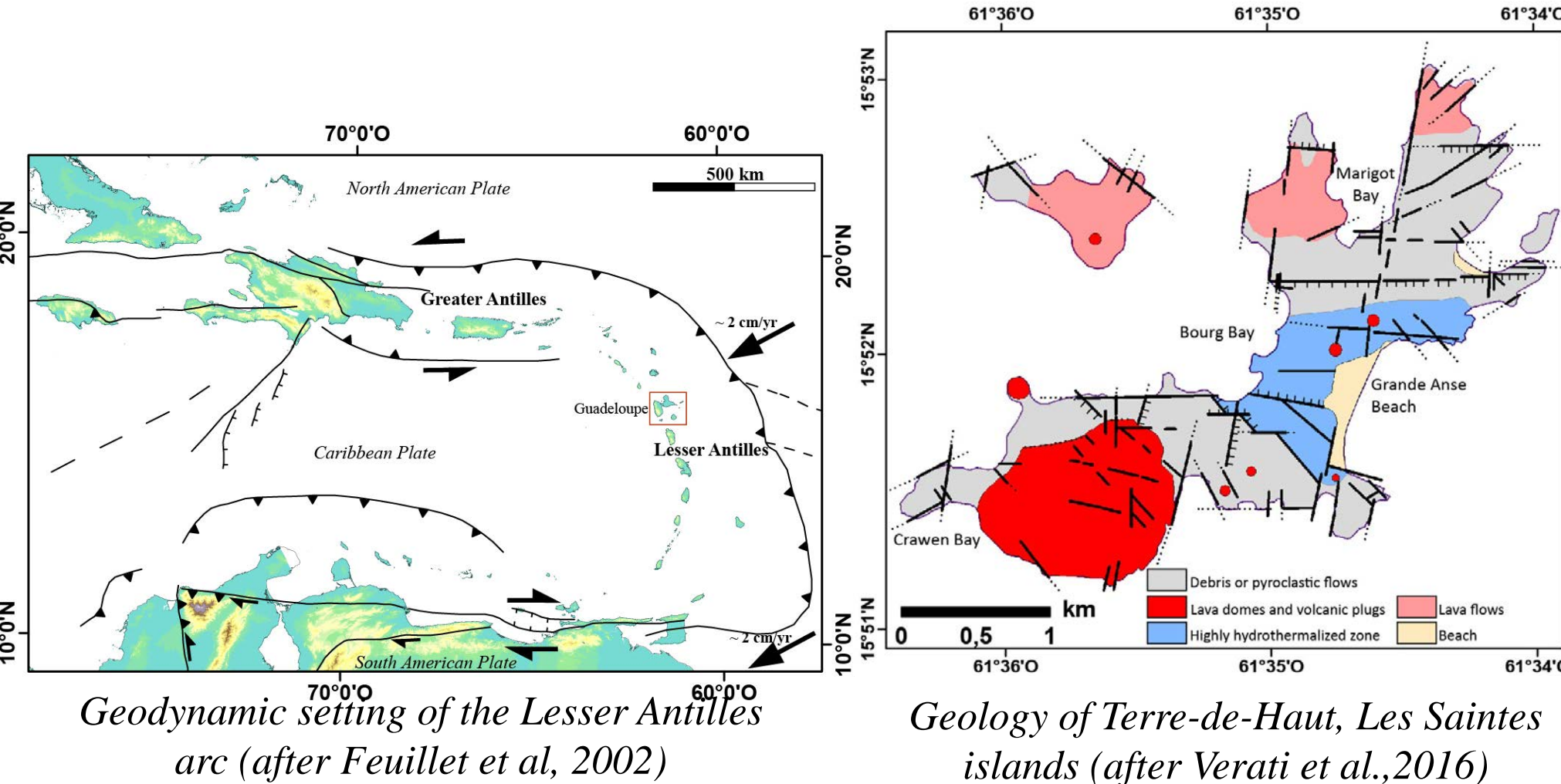
- Improve model of geothermal reservoir in volcanic context
  - Optimizing exploratory drilling targets to mitigate financial risks
  - Improving control over geothermal resource exploration process
  - Adapting methods routinely used in Oil & Gas exploration and production to geothermal energy
  - Focusing on fractured reservoir characterization and modelling
- Step 1. R&D :** Developing innovative methods and workflows leading to software tools  
**Step 2. Demonstration :** Applying those tools to a Caribbean prospect

GEOTREF is a four-year R&D program carried out by a consortium with internationally recognized expertise and experience

GEOTREF aims to be an innovative and complete tool for geothermal development and is therefore supported by the French state through the « Investments for the Future » financing program

## Study zone and geological context

The Lesser Antilles is located in a relatively low velocity subduction zone. Several islands have a present-day volcanic activity. The Guadeloupe archipelago contains the only geothermal plant in the Carribees.



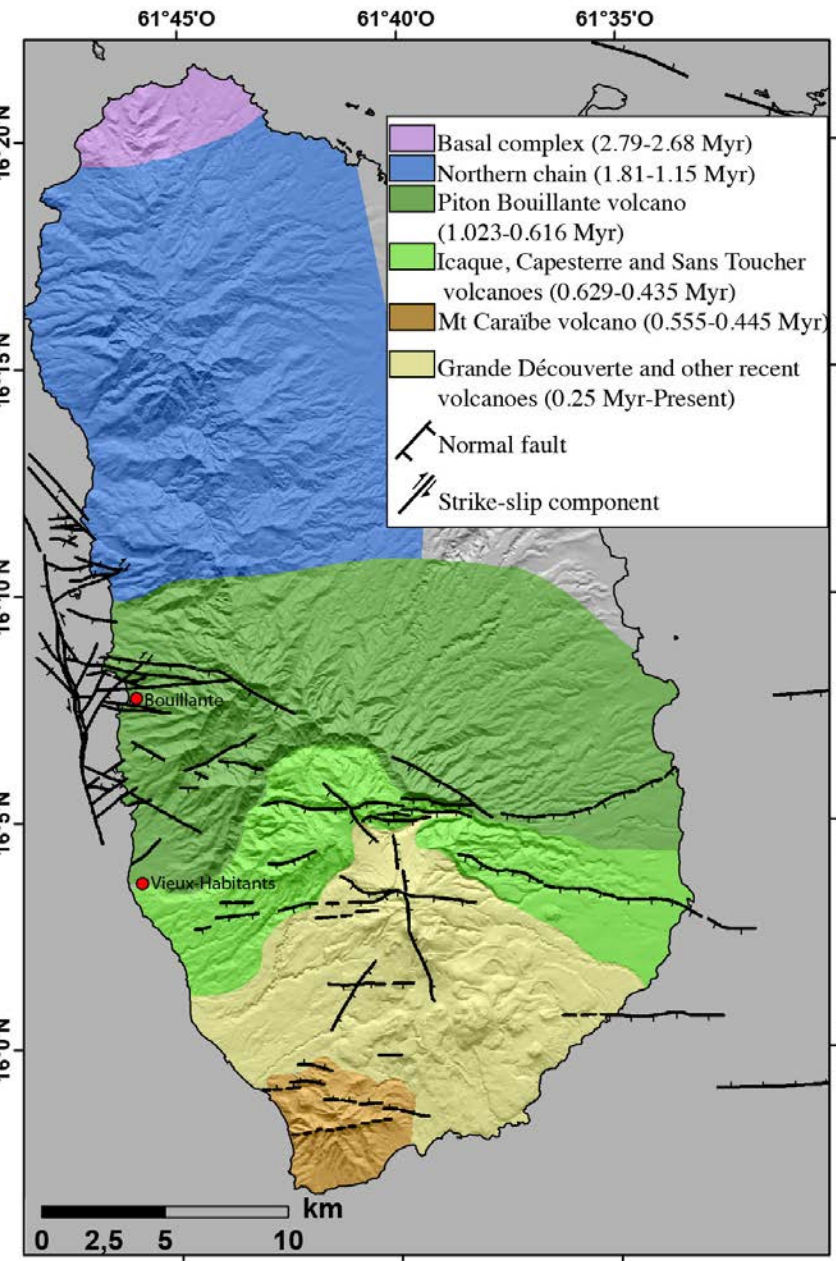
### Study zones on 2 islands composed of calc-alkaline volcanic rocks:

#### •Basse Terre :

Volcanic activity between 2.79 Myr - present. A geothermal plant is exploited in the Bouillante Bay since 1985 providing 7 % of the electrical needs. The target zone of the GEOTREF project is located in the Vieux-Habitants area, 9 km south of Bouillante.

#### •Terre-de-Haut, Les Saintes :

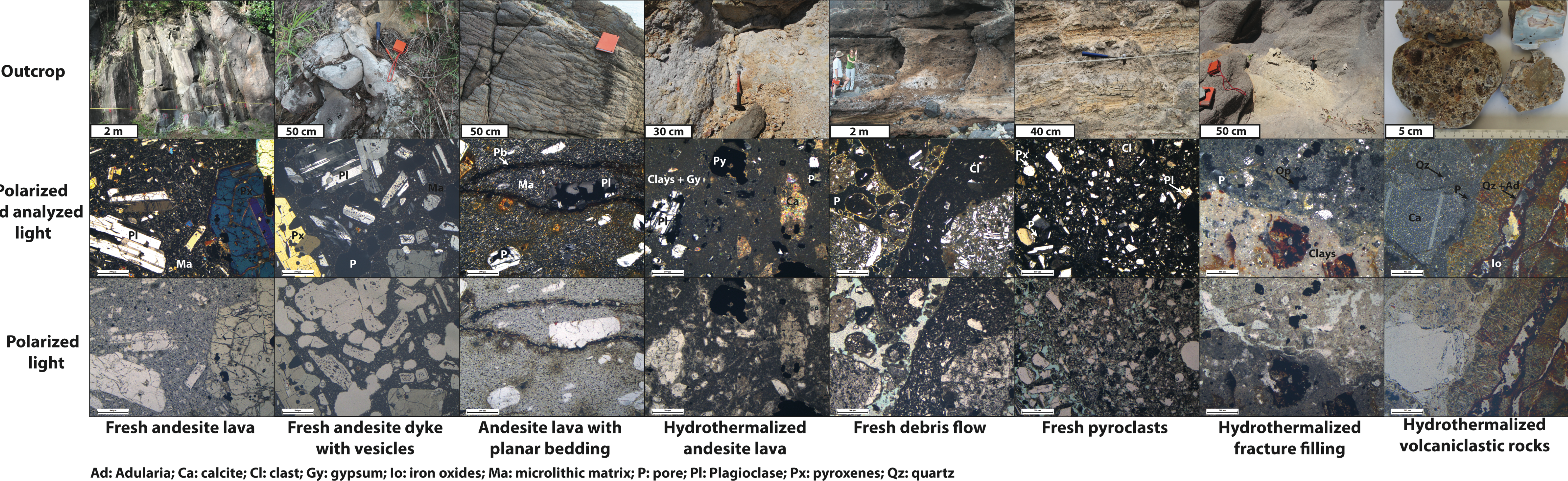
Volcanic activity between 2.98 and 2.00 Myr. A geothermal paleo-system is exhumed in the central part of the island. This paleo-system could be an analog of the geothermal reservoir exploited in Bouillante.



Geology of Basse-Terre (after Feuillet et al, 2002, Mathieu et al., 2011 and Samper, 2007)

## Material and methods

### 100 samples, 8 volcanic rock types

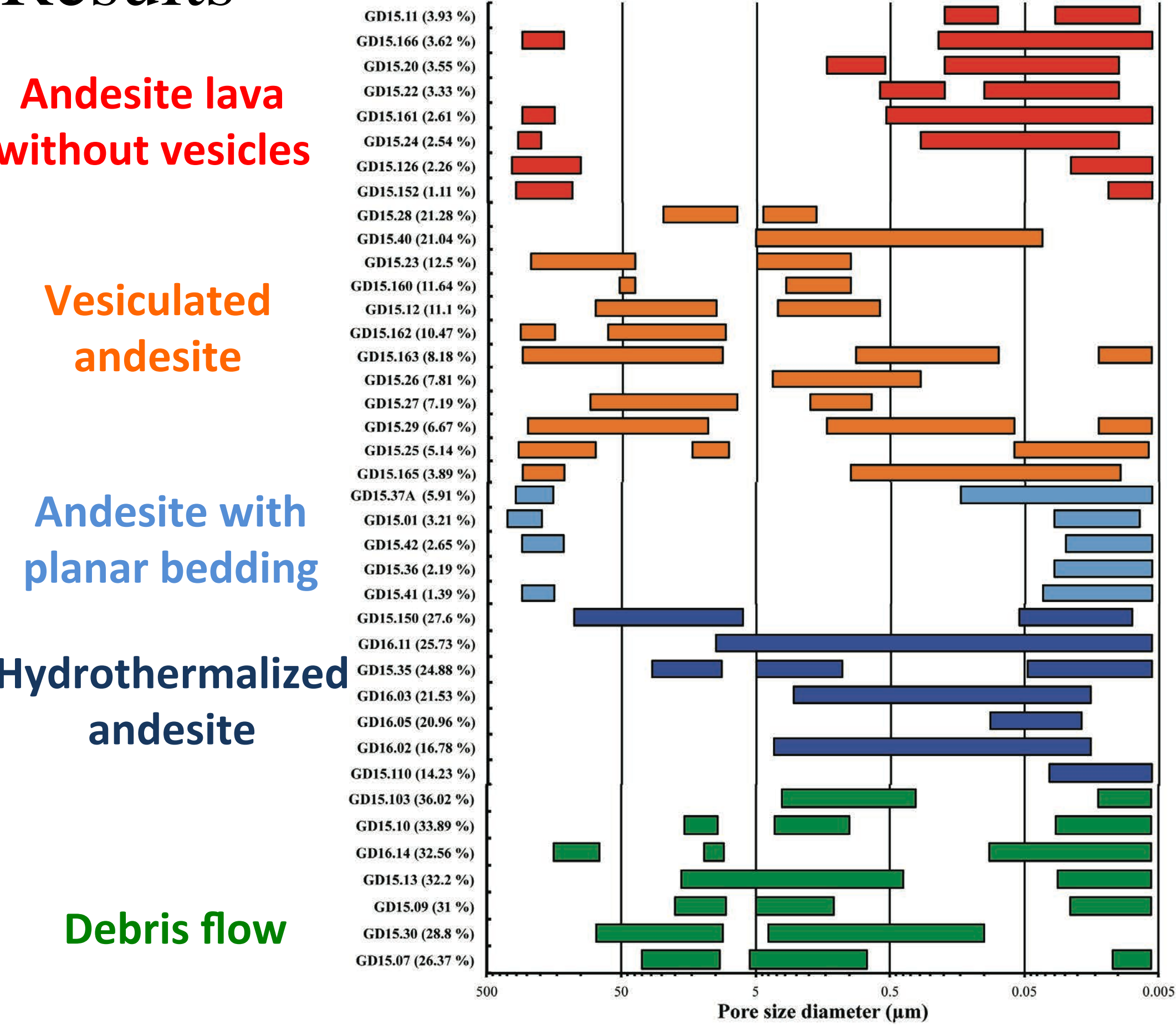


### Measurements

- Porosity (mercury, gas pycnometry, weighting method)
- Thermal conductivity and diffusivity
- Magnetic susceptibility
- Resistivity (expected)
- Permeability (portable and nitrogen permeameter)
- P-and S-waves velocities
- Bulk and skeletal densities

## Results

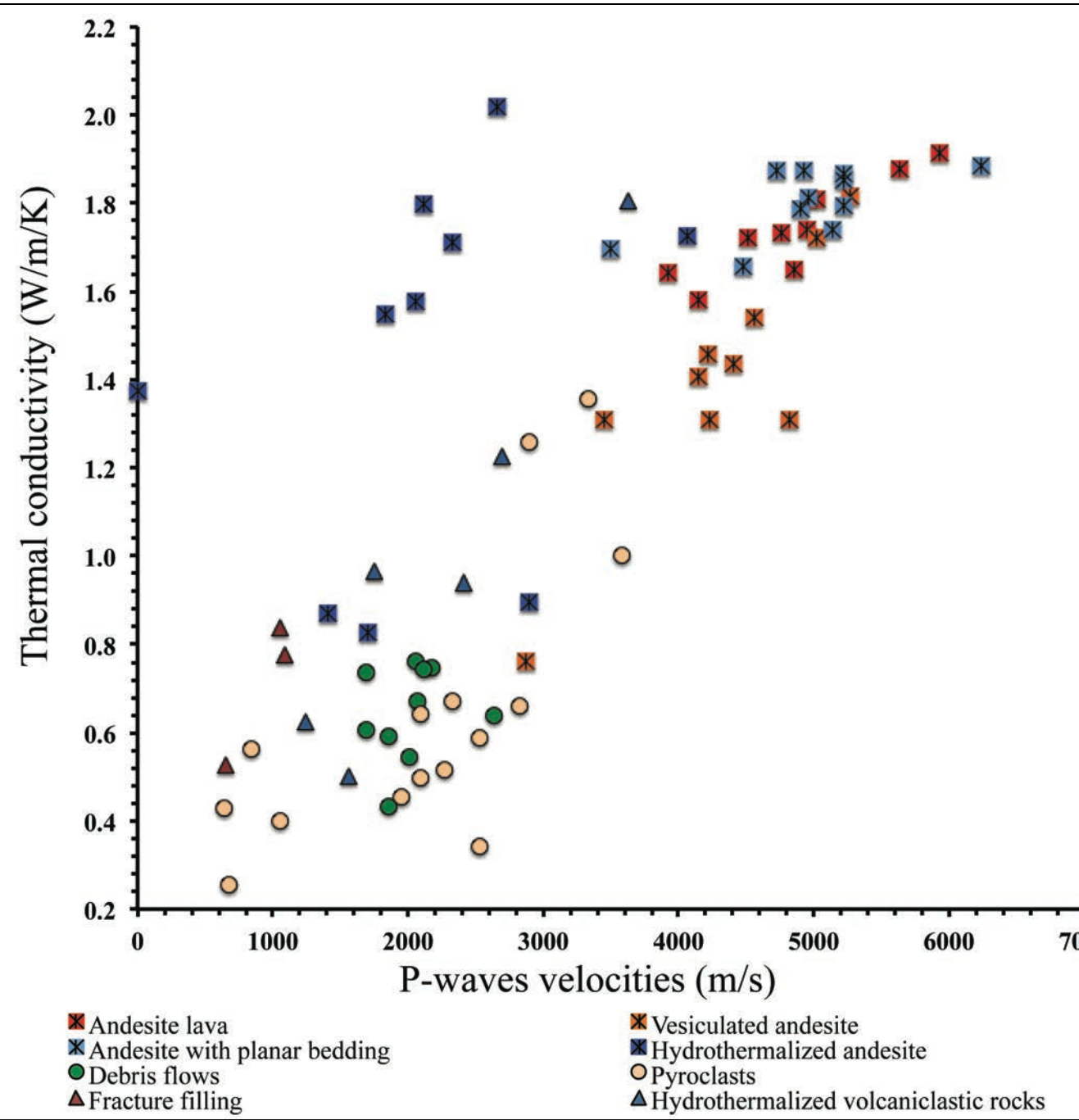
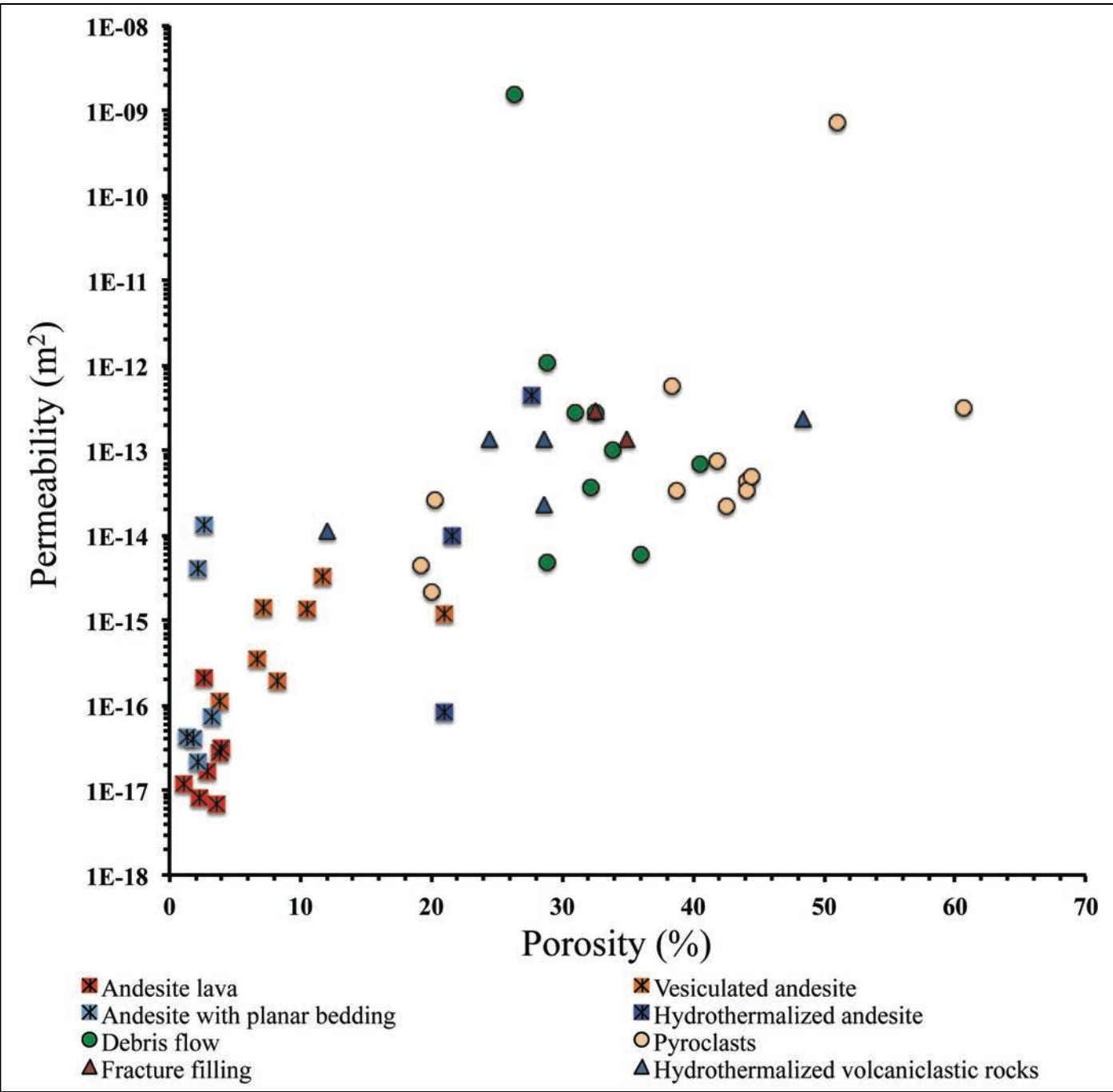
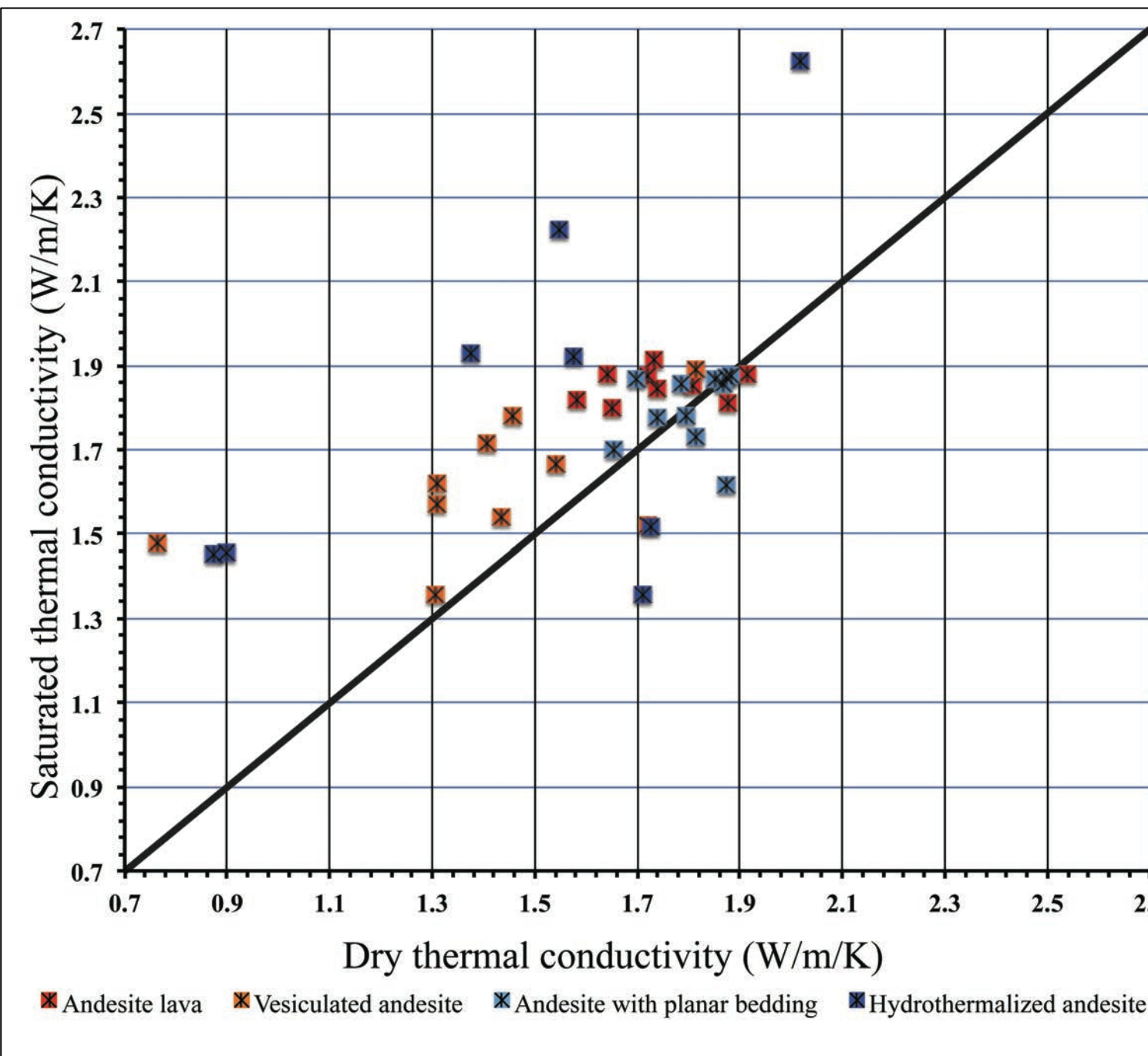
### Pore size diameter



### Summary of measured properties

Rock type	State	Sample number		$\rho_s$ [g.cm <sup>-3</sup> ]	$\rho_v$ [g.cm <sup>-3</sup> ]	$\Phi$ [%]	$K$ [m <sup>2</sup> ]	$V_p$ dry [m.s <sup>-1</sup> ]	$V_p$ saturated [m.s <sup>-1</sup> ]	$\lambda$ dry [W.m <sup>-1</sup> .K <sup>-1</sup> ]	$\lambda$ saturated [W.m <sup>-1</sup> .K <sup>-1</sup> ]	$C_p$ [kJ.kg <sup>-1</sup> .K <sup>-1</sup> ]	Magnetic susceptibility [x 10 <sup>-6</sup> SI]
Andesite lava	Fresh	Without vesicles	Median	2.68	2.75	3.11	1.6.10 <sup>-17</sup>	4858	5522	1.73	1.85	0.75	11.14
			Min - Max	2.59 - 2.74	2.69 - 2.83	1.11 - 3.93	6.9.10 <sup>-18</sup> - 2.09.10 <sup>-16</sup>	3920 - 5929	4878 - 5858	1.58 ± 1.91	1.80 - 1.91	0.70 - 0.81	6.22 - 26.8
	Fresh	With vesicles	Median	2.47	2.77	9.33	1.2.10 <sup>-18</sup>	4320	4836	1.42	1.6	0.76	9.06
			Min - Max	2.17 - 2.68	2.69 - 2.82	3.89 - 21.27	1.1.10 <sup>-19</sup> - 3.29.10 <sup>-15</sup>	2876 - 5271	3298 - 5661	0.76 - 1.82	1.357 - 1.89	0.70 - 0.83	2.07 - 25.77
Pyroclasts	Fresh	Planar bedding	Median	2.57	2.64	2.49	7.19.10 <sup>-19</sup>	4958	5155	1.81	1.86	0.81	11.65
			Min - Max	2.42 - 2.62	2.54 - 2.70	1.39 - 10.25	2.1.10 <sup>-19</sup> - 1.3.10 <sup>-18</sup>	3502 - 6233	4190 - 5569	1.65 - 1.884	1.62 - 1.875	0.73 - 0.96	7.48 - 15.87
	Highly weathered or hydrothermalized		Median	2.00	2.63	21.53	9.95.10 <sup>-18</sup>	2088	2177	1.55	1.72	0.89	12.46
			Min - Max	1.60 - 2.45	2.50 - 2.80	6.7 - 35.9	8.3.10 <sup>-19</sup> - 4.4.10 <sup>-18</sup>	≤ MT* - 4063	≤ MT* - 4377	0.83 - 2.02	1.36 - 2.63	0.69 - 1.06	-0.04 - 27.62
Debris flows	Fresh		Median	1.65	2.64	33.02	1.01.10 <sup>-18</sup>	2035	-	0.66	-	0.88	8.00
			Min - Max	1.51 - 2.25	2.49 - 2.79	16 - 40.5	4.8.10 <sup>-19</sup> - 1.5.10 <sup>-18</sup>	1697 - 2639	-	0.43 - 0.76	-	0.29 - 1.05	4.89 - 16.6
Fracture filling	Highly weathered or hydrothermalized		Median	1.46	2.64	40.57	3.83.10 <sup>-14</sup>	2273	-	0.50	-	0.83	6.92
			Min - Max	0.62 - 2.25	2.21 - 2.79	19.2 - 76.1	2.1.10 <sup>-15</sup> - 7.2.10 <sup>-14</sup>	634.9 - 3584	-	0.26 - 1.36	-	0.53 - 1.19	4.05 - 19.33
Volcaniclastic rocks	Hydrothermalized		Median	1.39	2.37	39.17	-	1059	-	0.81	-	-	-
			Min - Max	1.26 - 1.58	2.16 - 2.50	25.9 - 51.6	1.3.10 <sup>-15</sup> - 2.9.10 <sup>-15</sup>	648 - 1088	-	0.53 - 0.84	-	1.01	5.62 - 9.38
			Median	1.85	2.59	28.66	9.99.10 <sup>-14</sup>	2083	-	0.94	-	0.88	4.61
			Min - Max	1.26 - 2.30	2.17 - 2.67	12.0 - 48.4	1.1.10 <sup>-15</sup> - 2.4.10 <sup>-15</sup>	1247 - 3623	-	0.50 - 1.80	-	0.72 - 0.93	-0.11 - 18.37

MT\* : Measurement Threshold



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