

SAPHYR: Swiss Atlas of Physical Properties of Rocks

[Additional file 1](#)

S1. Dbase data Literature: list of literature from where physical properties were extracted

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S2. Lithology list for SAPHYR lithology groups, and corresponding lithology types from the geotechnical map of Switzerland version 1/2000 (GK500) (Federal Office of Topography swisstopo, 2006)

SAPHYR Lithology group	Lithology type description from the Geotechnical Map of Switzerland	GeoTech ID ¹
LG 1: Marl	Marl with badly consolidated sand, pebbles or debris layers	10
	Marl with layers of shell-rich sandstone to breccia	12
	Marls and slaty clays with banks of limestone, dolomite or sandstone	13
	Marl with dense sandstone layers	15
	Marl with layers of dense shell-rich sandy breccia	17
LG 2: Silt-, Mud-, Claystone	Marly clay and shale with banks of carbonate or sandstone	13
	Ferrous clay	14
	Slate with layers of limestone/gypsum/sandstone/rauhwacke	18
	Slate to phyllite with sandstone or breccia/conglomerate layers	30
	Marly slate to calc-phyllite with layers of sandstone	31
	Marly slate to calc-phyllite with layers of tuff sandstone	33
LG 3: Limestone	Limestone with layers of dolomite	38
	Limestone, frequently with marly layers	40
	Limestone, often a bit marly	41
	Limestone with clear layers of (calc) marl and marly slate	42
	Calcareous gravel	43
	Coarse limestone with layers of marly slates	44
LG 4: Sandstone	Predominantly calcareous, porous sandstone with layers of marl	11
	Sandstone with layers of marl	16
	Quartz-sandstone to sandy slate	19
	Sandstone and marl layers with unconsolidated conglomerate	21
	Dense sandstone with layers of marly slate and calc-phyllite	32
	Glaucinite quartz sandstone with echinoderm fragments	45
LG 5a: Conglomerate & LG 5b: Breccia	Conglomerate with sandstone and marl layers	20
	Conglomerate/breccia with arkose and sandstone	22
LG 6: Calc-phyllite	Breccia and conglomerate	23
	Calcareous breccia or conglomerate	46
	Sericite-rich conglomerate and breccia	64
LG 7: Dolomite	Calc-phyllite to calc-micaschist	35
	Calc-phyllite to calc-micaschist with layers of marble	36
	Calc-phyllite to calc-micaschist with layers of green rocks	37
LG 8: Granite & Pegmatite	Dolomite, partly with limestone layers	47
	Dolomite and rauhwacke	48
	Dolomite with evaporite layers	49
LG 9: Syenite & Monzonite	Granite with transitions into quartz diorite and syenite	50
	Granite with sericite, epidote and chlorite	51
LG10a: Gabbro & LG10b: Diorites	Syenite	53
LG 11: Silicic effusives & Porphry	Diorite and gabbro	83
	Quartz porphyry	52
	Porphyrite and porphyrite tuff	54
LG 12: Marble	Volcanics and pyroclastics	75
	Limestone and marble	56
LG 13: Radiolarite & Chert	Dolomitic marble	57
	Radiolarite	58
LG 14: Gneiss	Mica/biotite/feldspar gneiss with mixed structures	59
	Feldspar-rich gneisses	60
	Feldspar gneiss with sericite/chlorite/epidote overprint	61
	Mica/biotite/feldspar gneiss with homogeneous structures	65
	Platy mica/biotite/feldspar gneiss	66

	Biotite/muscovite gneiss and micaschist	62
	Sericite/chlorite gneiss/schist	63
LG 15: Schist & Metapelite	Mica/biotite gneiss with bright, often green phengite	67
	Mica/biotite gneiss, with chlorite, calc-silicates or quartzite	68
	Quartz/sericite/chlorite gneiss/schist with amphibolite layers	637
LG 16: Quarzite	Quartzite	69
	Quartz-phyllite	55
LG 17: Amphibolite	Amphibolite with transitions to diorite and hornblende gneiss	80
	Mixture zone between amphibolite and gneiss	84
LG 18: Serpentinite	Serpentinite	70
LG 19: Peridotite	Peridotite and dunite	71
LG 20: Eclogite	Greenschist with transitions to basic extrusives and eclogite	81
LG 21: Ice	Glaciers	99
	Silt to sand bodies, with gravel, rocks and debris blocks	110
	Silt to silty sands, often clayey, mostly calcareous	111
LG 22: Unconsolidated deposits	Clayey silt to clay with sandy layers	112
	Gravel and sand	120
	Gravel and sand, partially with clay or silt layers	130
	Sand, gravel, pebbles, stones and debris blocks	131
	Debris blocks and scree material	132
LG 23	Evaporite	-
LG 24	Kinzigite	-
LG 25	Stronalite	-
Water	Surface water and lakes	90

¹ from the digital geotechnical map of Switzerland, Version 1/2000 (Federal Office of Topography swisstopo, 2006)

Samples from literature that could not be attributed to any specific lithological groups were the following:

- Xenolithes: the term is too generic to be attributed to a specific lithological type;
- Mylonites: the term refers to a structural character and can be attributed to every rock type that underwent very high ductile deformation;
- Cataclasite/kakrite: the term refers to a structural character and can be attributed to every rock type that underwent brittle deformation;
- Lamprophyres: this is a generic term for rare potassium-rich mafic igneous rocks, that do not fit the classical classification schemes;
- Granophyres: the term is more linked to a texture (granophyric) than to a rock type;
- Fels: generic term to indicate "rock", might be identified as hornfels, a product of contact metamorphism, but still too generic to be attributed to a specific rock type.

Migmatites and leucosomes could be grouped in a LG but they might be extremely different in chemistry, structure and moreover they are not mapped in the geotechnical map of Switzerland. Therefore it was decided not to group them in any LG.

Basalts were not grouped in a LG because to date we only have a few samples, and they are either mixed with clay or have a slightly different chemistry (diabase), or they are weathered.

Additional rock types that were not attributed to a specific LG were either represented by a single or only a few samples, or they were extremely dispersed in chemical, mineralogical or structural characteristics, or they were scarce in outcrops and/or not considered in the geotechnical map of Switzerland. Examples are: ignimbrites, latites, metapsammites, prasinites, pyriclasites, pyroxenites.

s3. Anisotropic properties

Physical Properties		Anisotropy	n. anisotropy data	Method **
Density	Bulk	-	-	
	Grain	-	-	
Porosity	Absolute	X	449	Perp/par to foliation or banding
	Open total*	-	-	
	Open macro-*	-	-	
	Open micro-*	-	-	
Permeability	Absolute	X	80	Perp/par to foliation or banding
Thermal prop.	Thermal conductivity	X	302	Perp/par to foliation or banding
	Thermal conductivity dry	X	342	
	Thermal conductivity wet	X	407	
	Specific heat capacity	-	-	
Heat production	²³⁸ U, ²³⁵ U, ²³² Th, ⁴⁰ K content	-	-	
	Volumetric heat generation	-	-	
Magnetic prop.	Bulk Susceptibility	X	207	Max-Min
Seismic prop.	Ultrasound velocity of P waves	X	359	Max-Min/mean
	Vp pressure derivative	-	-	
	Vp temperature derivative	-	-	
	Ultrasound velocity of S waves	X	77	Max-Min/mean
	Vs Pressure derivative	-	-	
	Vs Temperature derivative	-	-	

*Only borehole data ** see below

Methods description:

1. Par/perp to foliation or banding: measurement are taken on samples perpendicular and parallel to planar structures such as layers or banding (sedimentary rocks and partially igneous rocks) or foliation (metamorphic rocks), the anisotropy can be calculated as the ratio of the Perpendicular over the parallel measurement.
2. Max-Min: measurements are taken along main structural directions (perpendicular to foliation or bedding, parallel and perpendicular to lineation in the foliation plane if foliation is developed, or two mutually perpendicular directions in the bedding plane if no lineation is developed). The anisotropy is defined as the difference between the max value and the min value measured. The unit is the one of the measured property.
3. Max-Min/Average: measurements are taken along main structural directions (perpendicular to foliation or bedding, parallel and perpendicular to lineation in the foliation plane if foliation is developed, or two mutually perpendicular directions in the bedding plane if no lineation is developed). Anisotropy is defined as the difference between max and min values divided by the mean over the three measured values.

s4. Dbase of physical rock properties

Grain density data for SAPHYR lithology groups (Density units in kg/cm³)

Lithology group	Description	Pop. n	Distribution	Max.	Average	Median	Min.	Standard deviation σ	σ -interval
LG 1	Marl	117	Normal	2951	2677	2700	2240	121	2556- 2798
LG 2	Silt-, Mud-, Claystone	231	Normal	2990	2694	2706	2367	104	2590-2798
LG 3	Limestone	228	Normal	2900	2694	2700	2410	61	2633-2755
LG 4	Sandstone	530	Normal	2895	2665	2670	2210	78	2588-2743
LG 5a,b	Conglomerate & Breccia	77	Positive Skew	2952	2718	2700	2560	98	2619-2816
LG 6	Calc-phyllite	7	Scatter	3015	2806	2770	2710	103	2703-2908
LG 7	Dolomite	134	Normal	2929	2796	2810	2620	58	2738-2854
LG 8	Granite ¹	181	Normal	2783	2652	2650	2470	50	2602-2702
LG 9	Syenite & Monzonite	33	Positive Skew	2940	2713	2690	2590	93	2620-2724
LG 10a	Gabbro	59	Positive Skew	3370	3040	3060	2670	154	2886-3194
LG 10b	Diorite	14	Positive Skew	2970	2825	2800	2720	82	2743-2907
LG 11	Si-Effusive & Porphyry	19	Normal	2890	2676	2680	2530	74	2602-2750
LG 12	Marble	45	Positive Skew	2914	2755	2750	2533	91	2664-2846
LG 13	Radiolarite & Chert	3	<i>Low Data n.</i>	<i>2719</i>	<i>2704</i>	<i>2712</i>	<i>2680</i>	<i>21</i>	<i>2683-2725</i>
LG 14	Gneiss	237	Normal	3046	2718	2710	2600	75	2643-2793
LG 15	Scist & Metapelite	75	Normal	2984	2777	2770	2600	75	2702-2852
LG 16	Quarzite	17	Normal	2860	2697	2660	2640	70	2627-2767
LG 17	Amphibolite	56	Negative Skew	3224	2986	3016	2510	145	2841-3132
LG 18	Serpentinite	32	Positive Skew	3060	2733	2705	2591	106	2627-2838
LG 19	Peridotite	23	Negative Skew	3354	3192	3264	2710	171	3021-3363
LG 20	Eclogite	8	Scatter	3436	3250	3250	3020	149	3101-3399
LG 21	Ice ²	-	-	-	918	-	-	-	-
LG 22	Unconsolid. sediments ³	-	-	2300	1700	-	1400	-	-
LG 23	Evaporite ⁴	67	Negative Skew	3020	2903	2940	2430	112	2791-3016
LG 24	Granodioriti & Tonaliti	36	Normal	2920	2707	2700	2464	81	2626-2788
LG 25	Kinzigite ⁴	11	Normal	2974	2851	2850	2710	88	2763-2939
LG 26	Stronalite ⁴	8	Positive Skew	3350	3092	3054	2960	122	2970-3213

In italic are the values of LGs with low data population.

¹Data include Pegmatites and Aplites

²Data from literature (Clark 1966; Harvey et al. 2017)

³Data from literature (Schön 2015)

⁴Not shown in the map

Bulk density data for SAPHYR lithology groups (Density units in kg/cm³)

Lithology group	Description	Pop. n	Distribution	Max.	Average	Median	Min.	Standard deviation σ	σ -interval
LG 1	Marl	96	Normal	2932	2578	2580	2096	137	2441- 2714
LG 2	Silt-, Mud-, Claystone	173	Normal	2970	2508	2500	1930	156	2352-2664
LG 3	Limestone	179	Normal	2823	2639	2677	2150	105	2533-2744
LG 4	Sandstone	452	Normal	2824	2457	2465	1860	171	2285-2627
LG 5a,b	Conglomerate & Breccia	76	Positive Skew	2934	2614	2675	2210	170	2444- 2784
<i>LG 6</i>	<i>Calc-phyllite</i>	<i>5</i>	<i>Low Data n.</i>	<i>2951</i>	<i>2776</i>	<i>2782</i>	<i>2620</i>	<i>126</i>	<i>2650-2902</i>
LG 7	Dolomite	145	Normal	2865	2540	2600	1940	251	2289-2792
LG 8	Granite ¹	119	Normal	2776	2606	2630	2310	91	2515-2697
LG 9	Syenite & Monzonite	17	Positive Skew	2850	2701	2710	2591	77	2620-2724
LG 10a	Gabbro	46	Positive Skew	3360	3048	3050	2781	139	2909- 3187
LG 10b	Diorite	8	Scattered	2984	2838	2833	2685	111	2727-2949
<i>LG 11</i>	<i>Si-Effusive & Porphyry</i>	<i>4</i>	<i>Low Data n</i>	<i>2722</i>	<i>2641</i>	<i>2665</i>	<i>2510</i>	<i>92</i>	<i>2549- 2733</i>
LG 12	Marble	38	Positive Skew	2984	2776	2754	2670	83	2693-2859
LG 13	Radiorite& Chert	7	Normal	2688	2620	2623	2533	53	2566-2673
LG 14	Gneiss	161	Normal	3032	2687	2693	2270	87	2600-2774
LG 15	Scist & Metapelite	22	Normal	2800	2715	2719	2600	56	2659-2771
LG 16	Quartzite	9	Normal	2730	2661	2650	2630	31	2630-2692
LG 17	Amphibolite	40	Normal	3220	3006	3015	2752	113	2893-3118
LG 18	Serpentinite	26	Positive Skew	2920	2706	2695	2554	93	2612-2799
LG 19	Peridotite	23	Negative Skew	3350	3193	3267	2700	164	3028-3357
<i>LG 20</i>	<i>Eclogite</i>	<i>5</i>	<i>Low Data n</i>	<i>3413</i>	<i>3225</i>	<i>3274</i>	<i>3000</i>	<i>196</i>	<i>3029-3421</i>
LG 21	Ice ²	-	-	920	917	917	840	-	-
LG 22	Unconsolid. sediments ³	-	-	2300	1776	2000	1000	421	1355-2197
LG 23	Evaporite ⁴	75	Negative Skew	3062	2831	2890	2100	175	2656-3007
LG 24	Granodioriti & Tonaliti	20	Normal	2819	2658	2671	2310	111	2548-2769
LG 25	Kinzigite ⁴	12	Normal	2907	2802	2795	2660	76	2726-2879
LG 26	Stronalite ⁴	15	Positive Skew	3330	2967	2992	2730	147	2820-3114

In Italic are LG data with low data population, not plotted on density maps

¹Data include Pegmatites and Aplites

²Data from literature (Shumisky 1960; Clark 1966; Harvey et al. 2017)

³Data from literature (Anselmetti et al. 2010)

⁴Not shown in the map

Vp0 data for SAPHYR lithology groups (Velocity units in km/s)

Lithology group	Description	Pop. n	Distribution	Max.	Average	Median	Min.	Standard deviation σ	σ -interval
<i>LG 1</i>	<i>Marl</i>	5	<i>Low data n.</i>	6.11	5.92	6.08	5.33	-0.33	5.59-6.25
LG 2	Silt-, Mud-, Claystone	12	Scattered	6.33	6.00	6.05	5.60	0.19	5.81-6.20
LG 3	Limestone	61	Negative Skew	6.60	6.06	6.16	4.67	0.43	5.63-6.49
LG 4	Sandstone	80	Negative Skew	6.26	5.41	5.58	3.74	0.57	4.83-5.98
LG 5a,b	Conglomerate & Breccia	35	Negative Skew	6.22	5.60	5.66	4.67	0.40	5.20-6.00
<i>LG 6</i>	<i>Calc-phyllite</i>	6	<i>Low data n.</i>	6.75	6.22	6.27	5.50	0.43	5.79-6.65
LG 7	Dolomite	68	Normal	7.00	5.92	6.06	4.20	0.73	5.18-6.65
LG 8	Granite ¹	35	Normal	6.49	5.82	5.87	4.95	0.28	5.53-6.10
LG 9	Syenite & Monzonite	1	Low data n.	-	-	-	-	-	-
LG 10a	Gabbro	32	Positive Skew	7.20	6.82	6.84	6.41	0.23	6.59-7.04
<i>LG10b</i>	<i>Diorite</i>	4	<i>Low data n.</i>	6.59	6.40	6.39	6.24	0.17	6.23-6.57
<i>LG 11</i>	<i>Si-Effusive & Porphyry</i>	3	<i>Low data n.</i>	5.69	5.43	5.57	5.01	0.36	5.06-5.79
LG 12	Marble	39	Normal	7.69	6.54	6.57	5.73	0.34	6.20-6.87
LG 13	Radiolarite& Chert	7	Normal	5.86	5.51	5.69	4.68	0.41	5.10-5.92
LG 14	Gneiss	69	Normal	6.34	5.82	5.85	5.11	0.28	5.54-6.09
LG 15	Schist & Metapelite	29	Normal	6.67	6.18	6.18	5.50	0.32	5.86-6.50
LG 16	Quartzite	8	Normal	5.91	5.79	5.80	5.66	0.10	5.69-5.89
LG 17	Amphibolite	35	Normal	7.20	6.52	6.50	5.95	0.33	6.19-6.85
LG 18	Serpentinite	22	Positive Skew	7.50	5.96	5.78	5.23	0.56	5.40-6.52
LG 19	Peridotite	18	Negative Skew	8.53	7.80	8.01	6.27	0.63	7.16-8.44
LG 20	Eclogite	2	Low data n.	-	-	-	-	-	-
LG 21	Ice ²	30	-	3.95	3.83	3.84	3.62	0.60	3.77-3.89
LG 22	Unconsolid. sediments ³	13	-	3.14	2.73	-	2.43	0.18	2.55-2.91
LG 23	Evaporite ⁴	7	Scatter	6.17	4.74	4.81	2.99	1.39	3.35-6.12
<i>LG 24</i>	<i>Granodioriti & Tonaliti</i>	6	<i>Scattered</i>	6.28	5.91	5.91	5.61	0.26	5.66-6.17
LG 25	Kinzigite ⁴	12	Normal	6.39	5.97	5.97	5.42	0.29	5.68-6.26
LG 26	Stronalite ⁴	15	Normal	7.18	6.60	6.61	6.06	0.37	6.23-6.96

In italic are the values of LGs with low data population.

¹Data include Pegmatites and Aplites

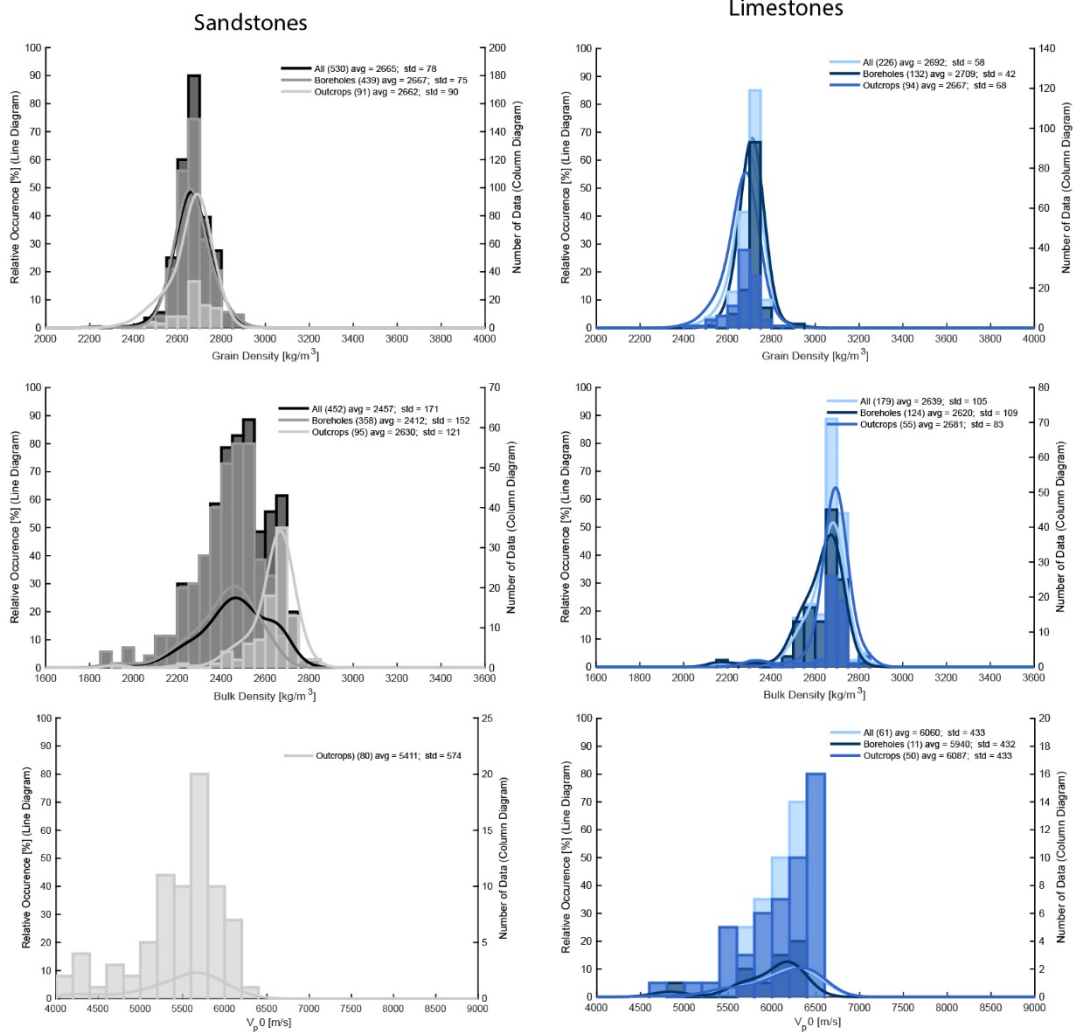
²Data from literature (Vogt et al. 2008, Vaughan et al. 2017)

³Data from literature (Mavko et al. 2009)

⁴ Not shown in the map

S5. Examples of physical properties statistical distribution

Examples of density distributions (S5.1) and thermal properties (S5.2), subdivided in outcrops and borehole (including tunnels). Diagrams show a visual comparison of block histograms and respective kernel distributions (solid lines) generated from the data population. Histograms refer to the number of data (on the right vertical axis) falling in a specific densities range (see figure 6 caption for further explanations).



Granites

