Filler comparison

Non black fillers in peroxid cured EPDM rubber – extrusion application

Author: Meier Julia

HOFFMANN MINERAL®
We supply materials for good ideas

Contents

Status Quo

Aim of the investigation:

Representation of the performance of Neuburg Siliceous Earth grades compared to competitors in a peroxide-cured EPDM formulation for extrusion applications.

The components of the formulation have been adapted to the latest specifications regarding raw materials and the accelerator system.

A hardness of approx. 70 Shore A was targeted.

Experimental

- Formulation
  - ¬ Formulation for the determination of the results after vulcanization and after aging
  - ¬ Formulation for extrusion
- Fillers
  - ¬ Neuburg Siliceous Earth (NSE)
  - ¬ Competitors
- Compounding and vulcanization
- Test standards - overview

Formulation for the determination of the results after vulcanization and after aging

Ingredients	Description	phr
Vistalon 7700	Ethylene propylene diene rubber ML 1+8 (125 °C): 115 MU	100
Zinkoxyd activ	Zinc oxide active	5
Edenor C18 98-100 GW	Stearic acid	2
Fillers	*Please see slides „Fillers“*	variable 300 / 180 / 150 / 90
DEG	Diethylene glycol	variable 0 / 2 / 5
Process Oil P 460	Paraffinic mineral oil, plasticizer	70
Kezadol GR	Calcium oxide, desiccant	10
TAC GR 70	Triallyl-cyanurate, 70 %, coagent	2.14
Perkadox 14-40B-pd-s	Di(tert-butylperoxyisopropyl)benzene, 40 %, peroxide	8
Total:		**max. 502.14 / min. 287.14**

Formulation for extrusion:

→ Extrusion was carried out without coactivator and cross linker.
In addition, 2 phr of the processing aid Aflux 42 were added

Ingredients	Description	phr
Vistalon 7700	Ethylene propylene diene rubber ML 1+8 (125 °C): 115 MU	100
Zinkoxyd active	Zinc oxide active	5
Edenor C18 98-100 GW	Stearic acid	2
Fillers	*Please see slides „Fillers“*	variable 300 / 180 / 150 / 90
DEG	Diethylene glycol	variable 0 / 2 / 5
Process Oil P 460	Paraffinic mineral oil, plasticizer	70
Kezadol GR	Calcium oxide, moisture binder	10
Aflux 42	Processing aids	2
Total:		**max. 494 / min. 279**

Fillers – Neuburg Siliceous Earth (NSE)

	phr (Filler)	phr (DEG)
Sillitin V 85	300	0
Sillitin V 88	300	0
Sillitin N 82*	300	0
Sillitin N 85	300	0
Sillitin Z 86	300	0
Sillitin Z 89	300	0
Sillikolloid P 87	300	0
		2

***Sillitin N 82 will be replaced by Sillitin N 75**

	Basic material	Calcination	Functionalization	phr (Filler)	phr (DEG)
Silfit Z 91	Sillitin Z 86	✓	-	300	0
Aktifit AM	Silfit Z 91	✓	Amino	300	0
Aktisil AM	Sillitin Z 86	-	Amino	300	0
Aktisil PF 216	Sillitin Z 86	-	Tetrasulfane	300	0
Aktisil VM 56	Sillitin Z 86	-	Vinyl	300	0
Aktisil VM 56/89	Sillitin Z 89	-	Vinyl	300	0
Aktisil MAM-R	Sillitin V 85	-	Methacrylic	300	0
Aktisil MAM	Sillitin V 88	-	Methacrylic	300	0
Aktisil Q	Sillitin V 90 *Internal product quality	-	Methacrylic	300	0
Aktisil PF 777	Sillitin Z 86	-	Alkyl	300	0

Fillers – Competitors

	Filler category	Calcination	Functionalization	phr (Filler)	phr (DEG)
Carbon black N 550	Carbon black N 550	-	-	150	0
Precipitated silica 180 m^2/g	Precipitated silica 180 m^2/g	-	-	90	0
					5
Precipitated aluminum silicate	Precipitated aluminum silicate	-	-	150	0
					2
Precipitated calcium silicate	Precipitated calcium silicate	-	-	180	0
					2
French Hard Clay	Hard Clay	-	-	300	0
					5
English Hard Clay	Hard Clay	-	-	300	0
					5
English Clay	Clay	-	-	300	0
					2
English Soft Clay	Soft Clay	-	-	300	0
					2

Fillers – Competitors

	Calcination	Functionalization	phr (Filler)	phr (DEG)
English calcined Clay	✓	-	300	0
American calcined Clay	✓	-	300	0
American calcined Clay, vinyl functionalized (T)	✓	Vinyl	300	0
American calcined Clay, amino functionalized	✓	Amino	300	0
American calcined Clay, vinyl functionalized (B)	✓	Vinyl	300	0
Whiting	-	-	300	0
Whiting, stearate functionalized	-	Stearic acid	300	0
American Talc	-	-	300	0
American coated Talc, amino functionalized	-	Amino	300	0

Compounding and vulcanization

Compounding	
Open mill	Ø 150 x 300 mm
Batch weight	approx. 1000 g
Mill temperature	50 °C
Mixing time	approx. 15 min.

Vulcanization	
The curing was carried out in a press at 180 °C	
Time	5 min. or t_{90} + 10 %

Test standards – overview

Testing	Standard
Mooney Viscosity ML 1+4 (100 °C)	DIN ISO 289-1
Mooney Scorch ML +5 (120 °C)	DIN ISO 289-2
Cure characteristics	DIN 53 529, part 1 – 4
Tensile test	DIN 53 504, S2
Compression set	DIN ISO 815-1, Type B
Hardness	DIN ISO 7619-1
Rebound elasticity	DIN 53 512
Tear resistance - Trousers specimen	DIN ISO 34-1, A
Resistance to liquid media	DIN ISO 1817
Resistance to air	ISO 188, D

Results

→ back to contents

- Garvey Extrusion
- Properties of raw compound
  - ¬ Mooney Viscosity ML 1+4 (100 °C)
  - ¬ Mooney Scorch ML +5 (120 °C)
  - ¬ Rotorless Cure Meter, 180 °C
- Properties of vulcanizate
- Hot air aging 168 h / 100 °C
- Hot air aging 168 h / 125 °C
- Immersion in deionized water 168 h / 95 °C

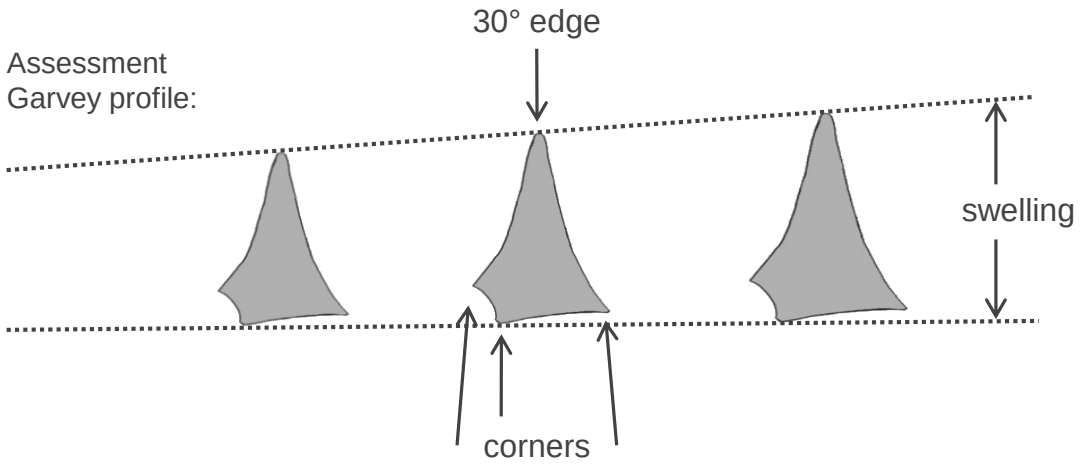
→ back to results

Garvey Extrusion

HOFFMANN MINERAL®
We supply materials for good ideas

Garvey Extrusion

Extruder		Schwabenthan Polyest 30 R
Screw diameter	[mm]	30
Process length	[mm]	450
Temperature set point head / Zone 1 / Zone 2	[°C]	150 / 40 / 40
Feeding strips		cold, untreated

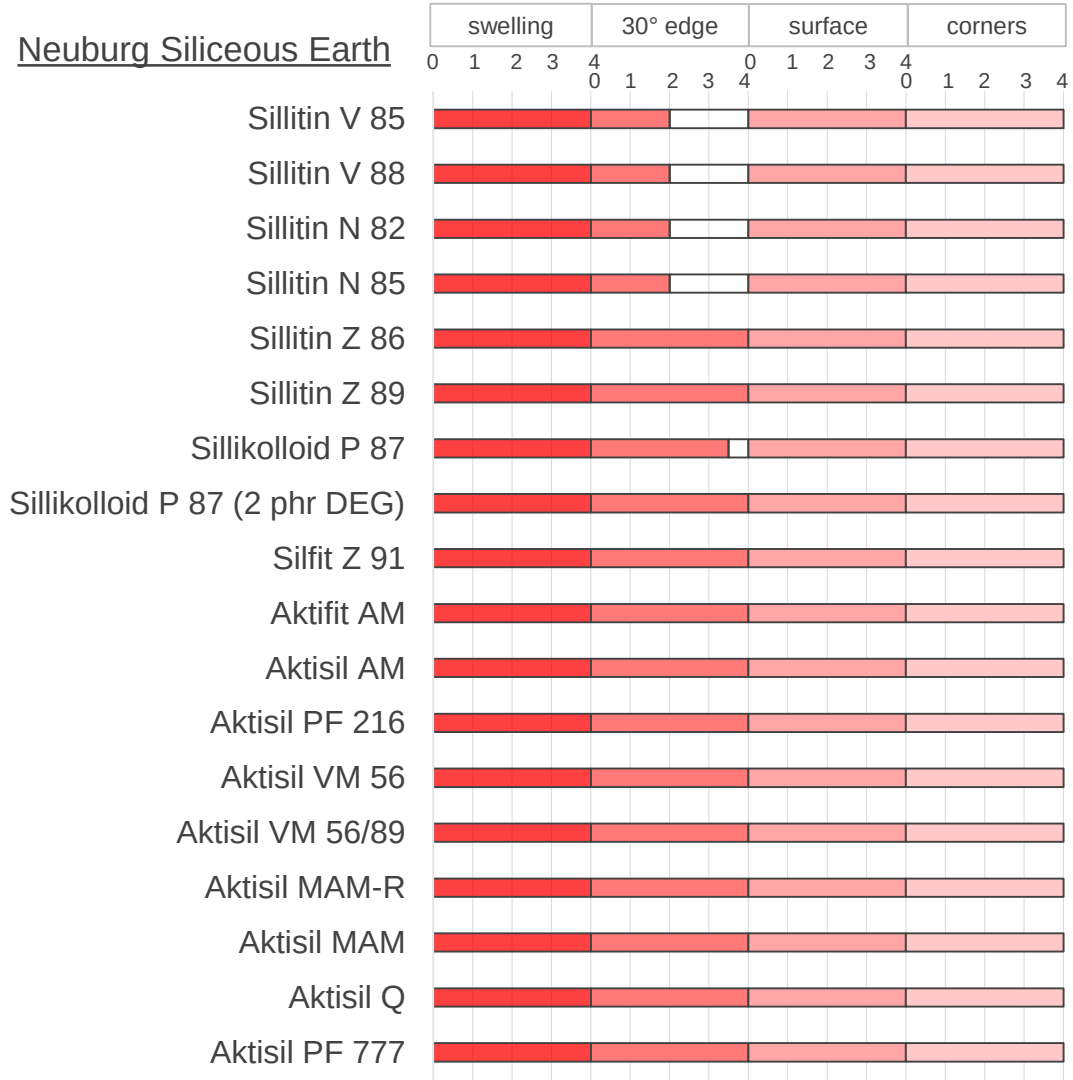


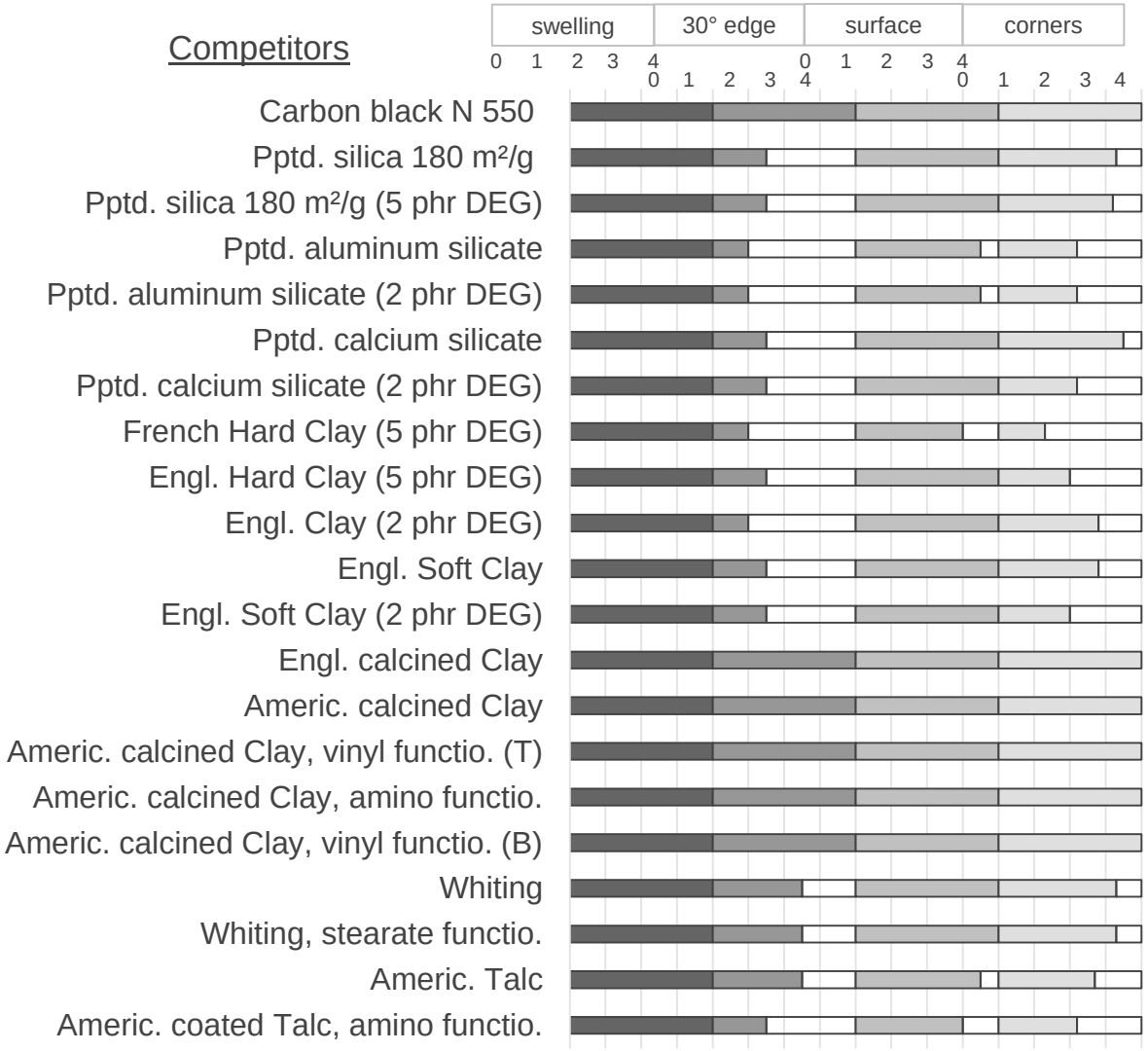
Garvey-die:

Assessment Garvey profile at 2.0 m/min. haul-off speed

according to ASTM D 2230-90

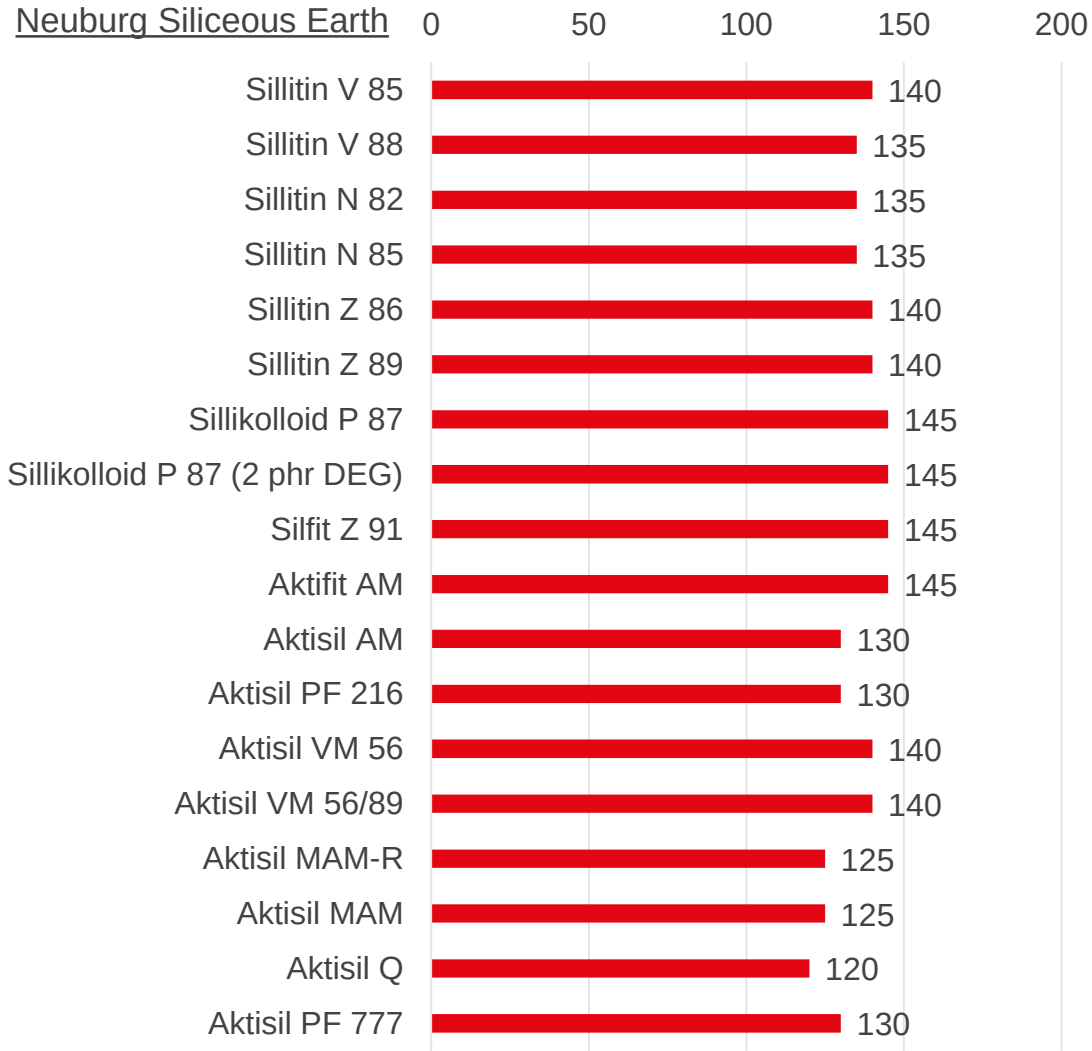
Images
Garvey-Extrudate

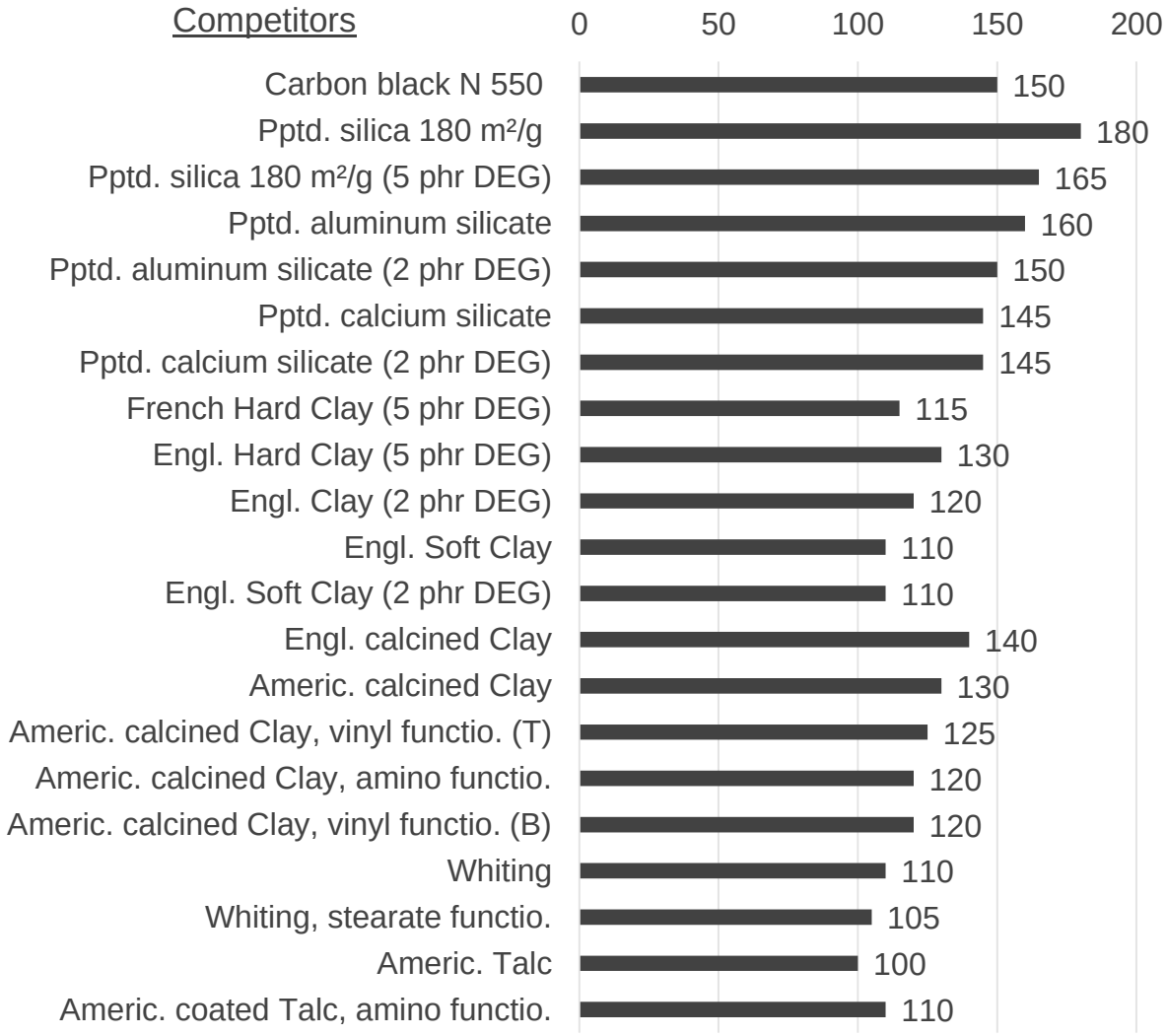




Note: Sillitin N 82 will be replaced by Sillitin N 75

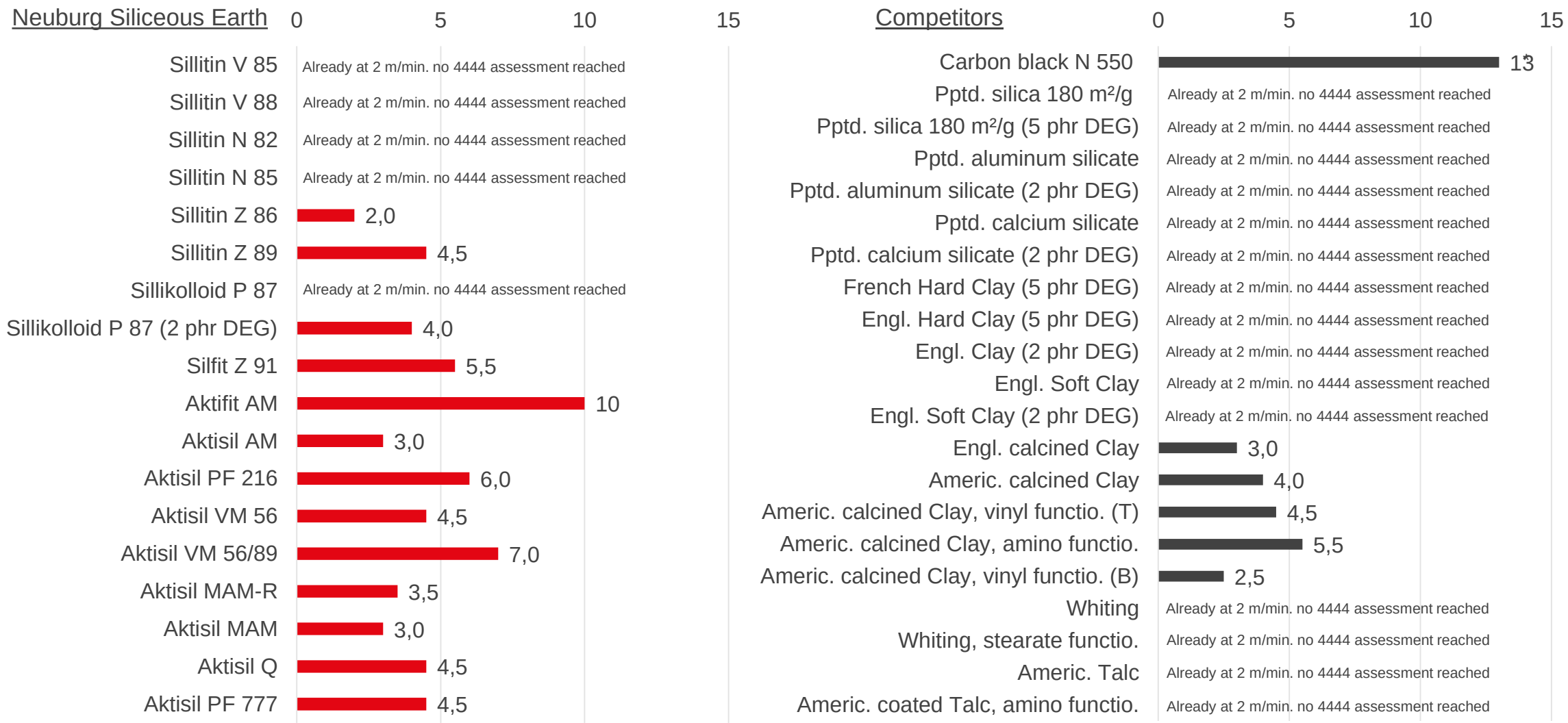
Extruder torque at 2.0 m/min. in Nm





Note: Sillitin N 82 will be replaced by Sillitin N 75

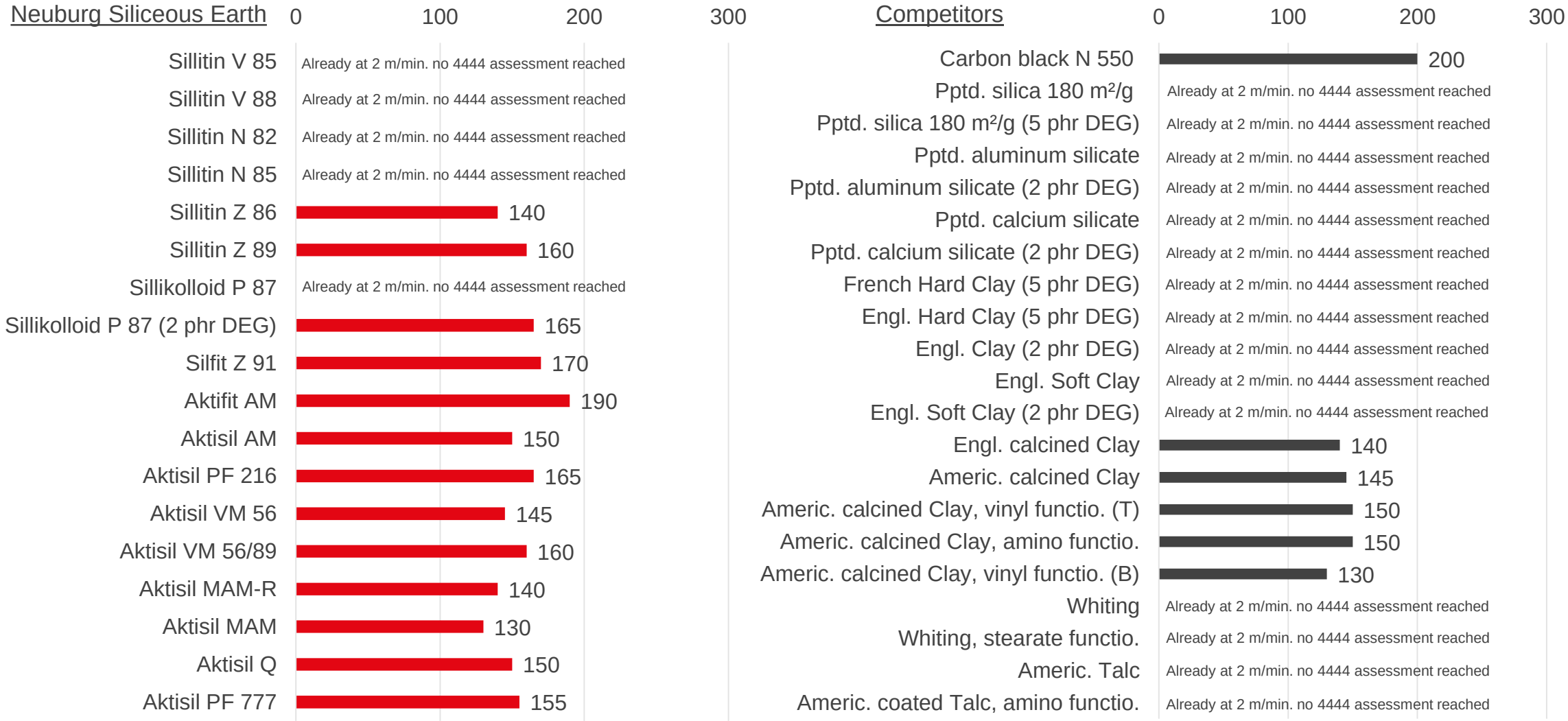
Max. Extrusion speed with Garvey profile 4444
Haul-off speed in m/min.



* higher speed possible

Note: Sillitin N 82 will be replaced by Sillitin N 75

Max. Extrusion speed with Garvey profile 4444
Extruder torque in Nm



Note: Sillitin N 82 will be replaced by Sillitin N 75

Summary Garvey extrusion:

Special features of Neuburg Siliceous Earth in peroxide-cured EPDM rubber for extrusion applications (Sillitin, Aktisil, Silfit, Aktifit)

Neuburg Siliceous Earth has positive characteristics:
Compared to the competitors, twice as many NSE products achieve the 4444-Garvey rating at the same haul-off speed.
Comparable extruder torque with higher haul-off speed with functionalized and/or calcined NSE versus calcined (and functionalized) kaolin.

Garvey rating at 2.0 m/min haul-off speed:
- almost all Neuburg Siliceous Earth grades achieve the full 4444-Garvey profile rating
- average extruder torque is 135 Nm
- lowest extruder torque with 4444-Garvey profile rating achieved Aktisil Q with 120 Nm

Garvey profile at maximum extrusion speed with 4444 rating:
- maximum haul-off speed achieved Aktifit AM with 10 m/min.
- average extruder torque is 155 Nm
- lowest extruder torque with 4444-Garvey profile rating achieved Aktisil MAM with 130 Nm

DEG Addition:
The DEG addition to Sillikolloid P 87 made it possible to achieve a 4444-Garvey profile rating.
The maximum extrusion rate for a 4444 rating could be increased twofold.

→ back to results

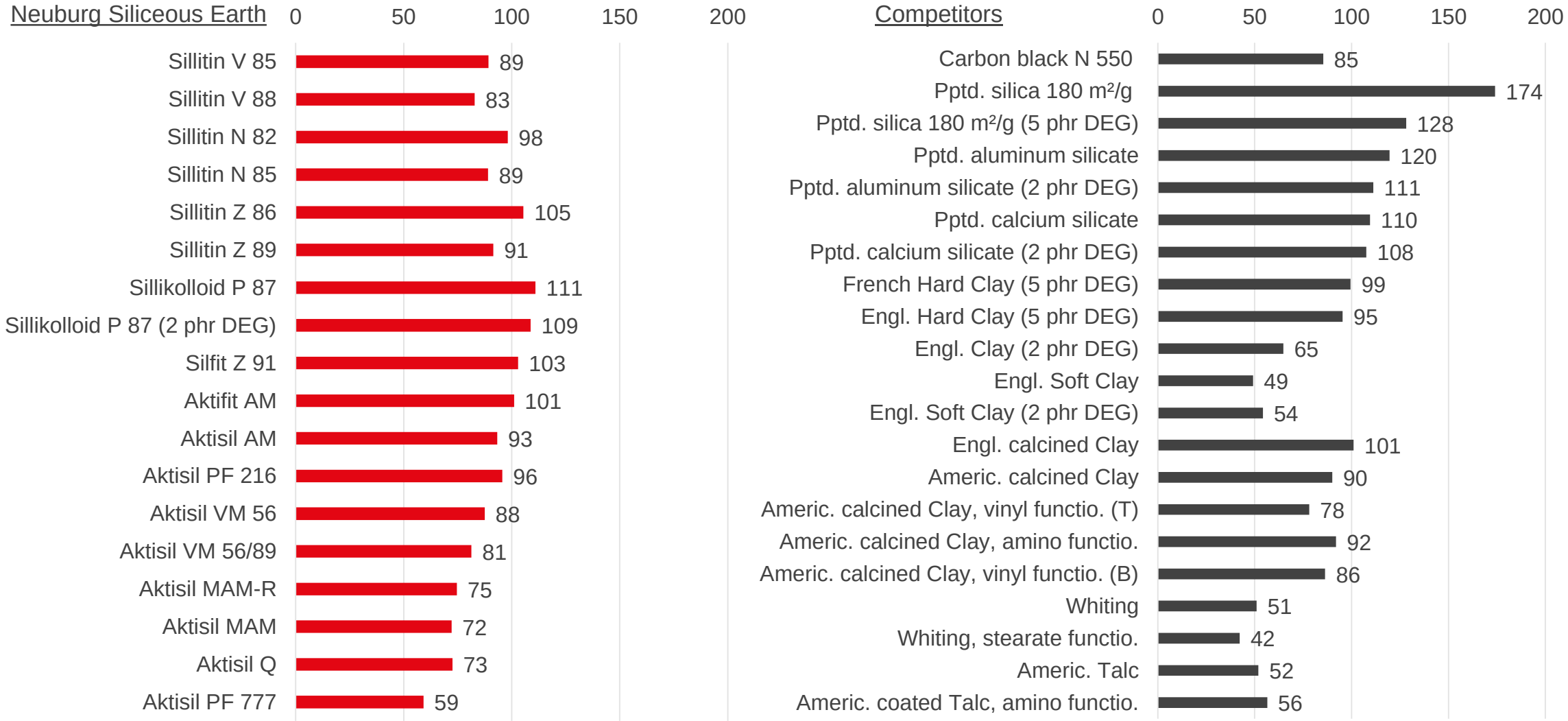
Properties of raw compound

DIN ISO 289-1
DIN ISO 289-2
DIN 53 529, part 1 – 4

HOFFMANN MINERAL®
We supply materials for good ideas

Mooney Viscosity ML 1+4 (100 °C) in MU

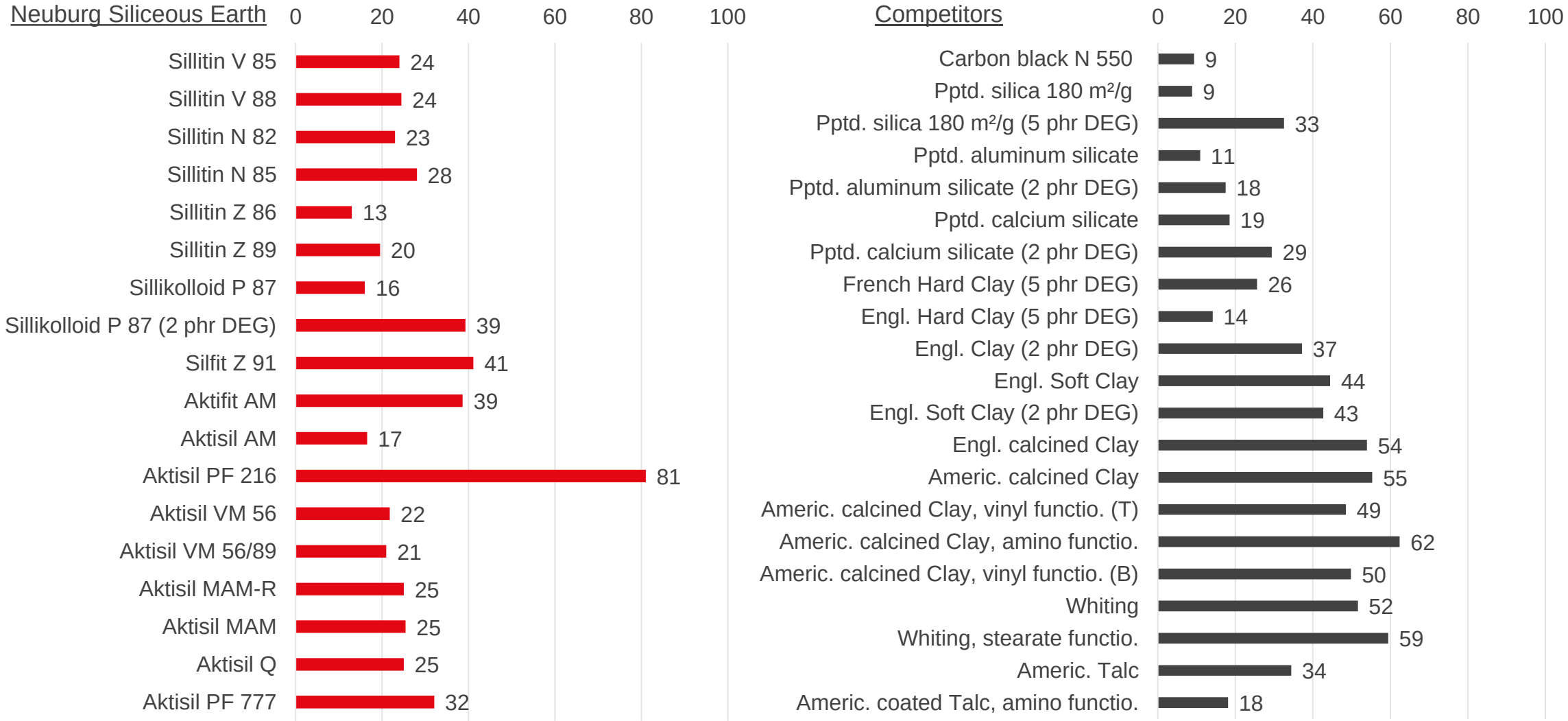
DIN ISO 289-1



Note: Sillitin N 82 will be replaced by Sillitin N 75

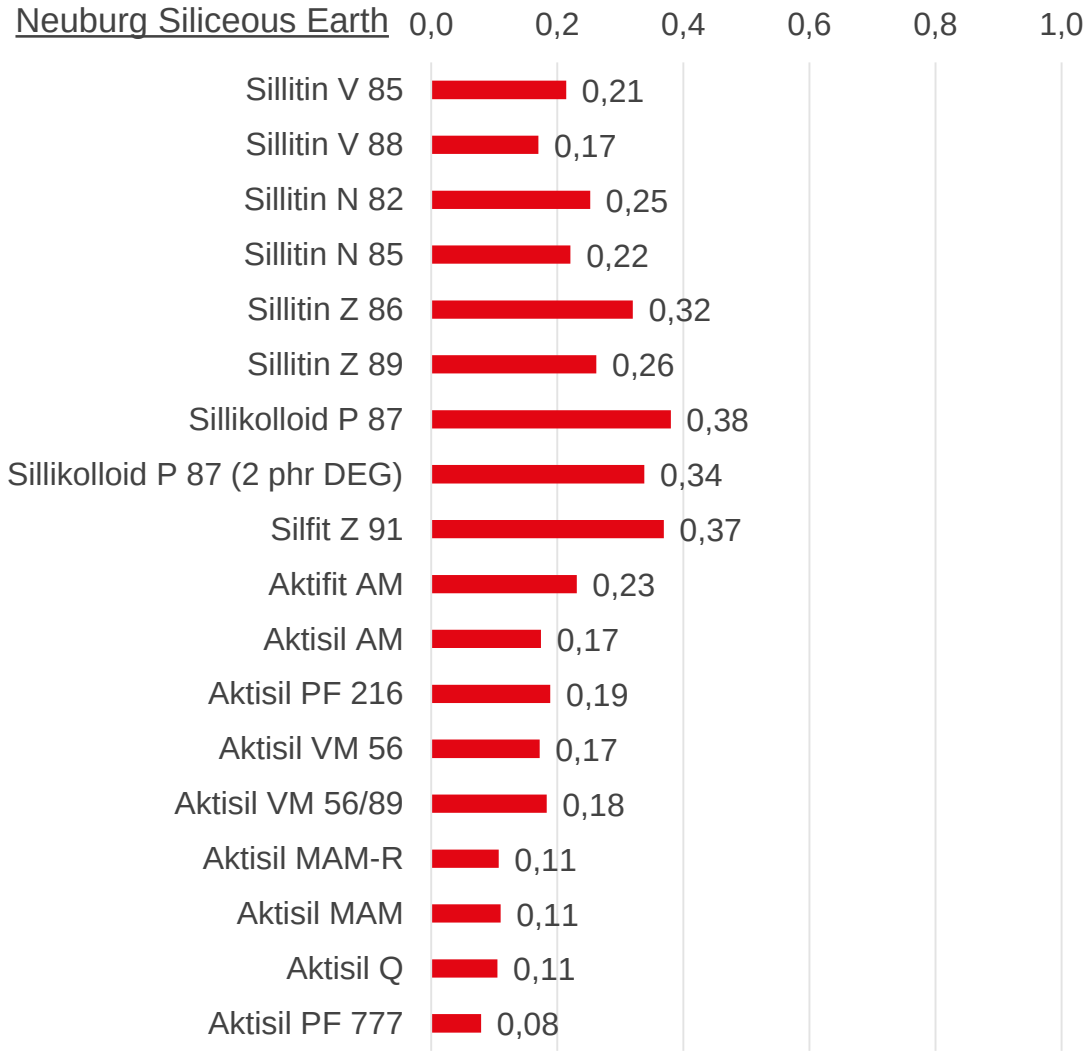
Mooney Scorch ML +5 (120 °C) in min.

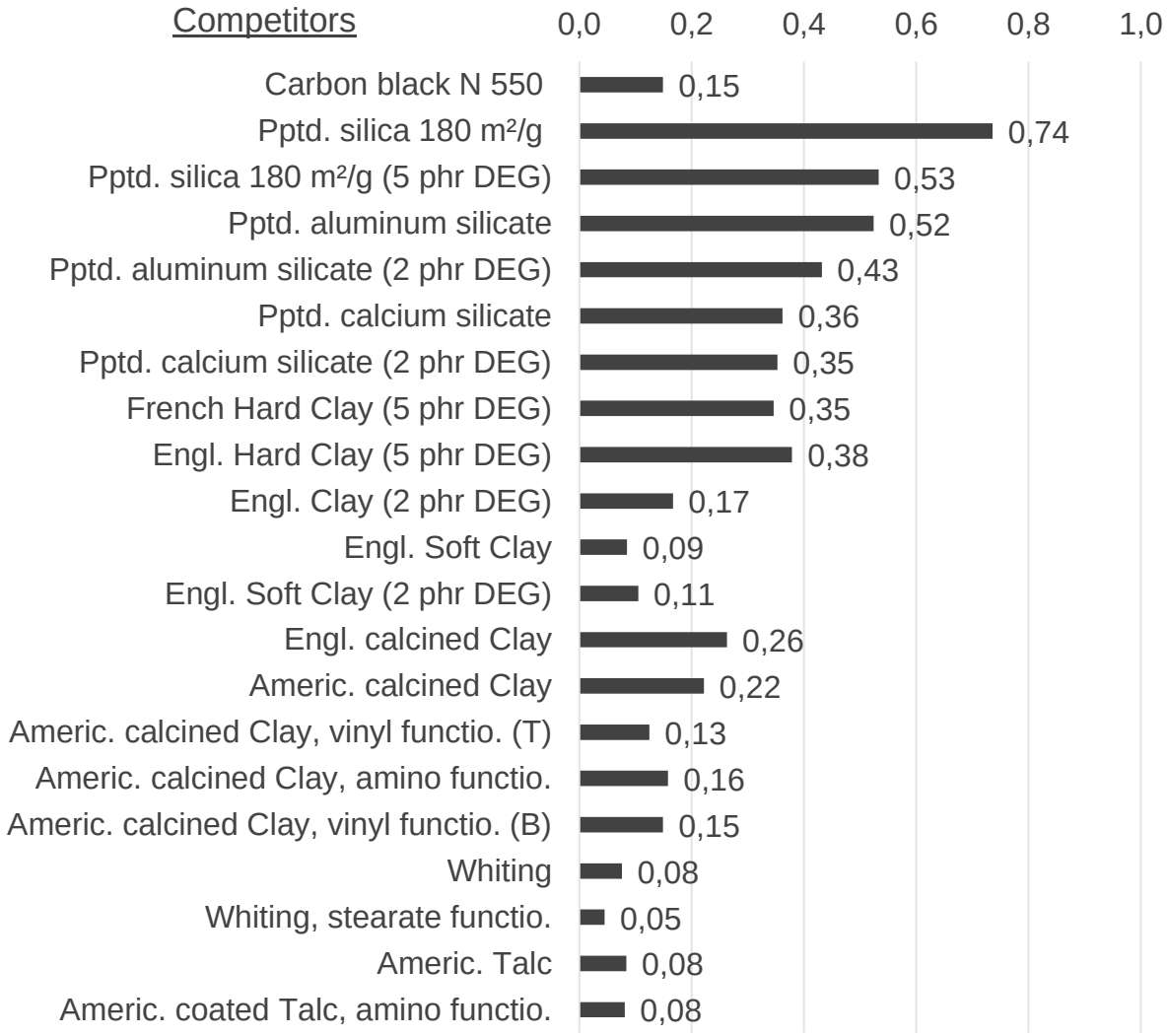
DIN ISO 289-2



Note: Sillitin N 82 will be replaced by Sillitin N 75

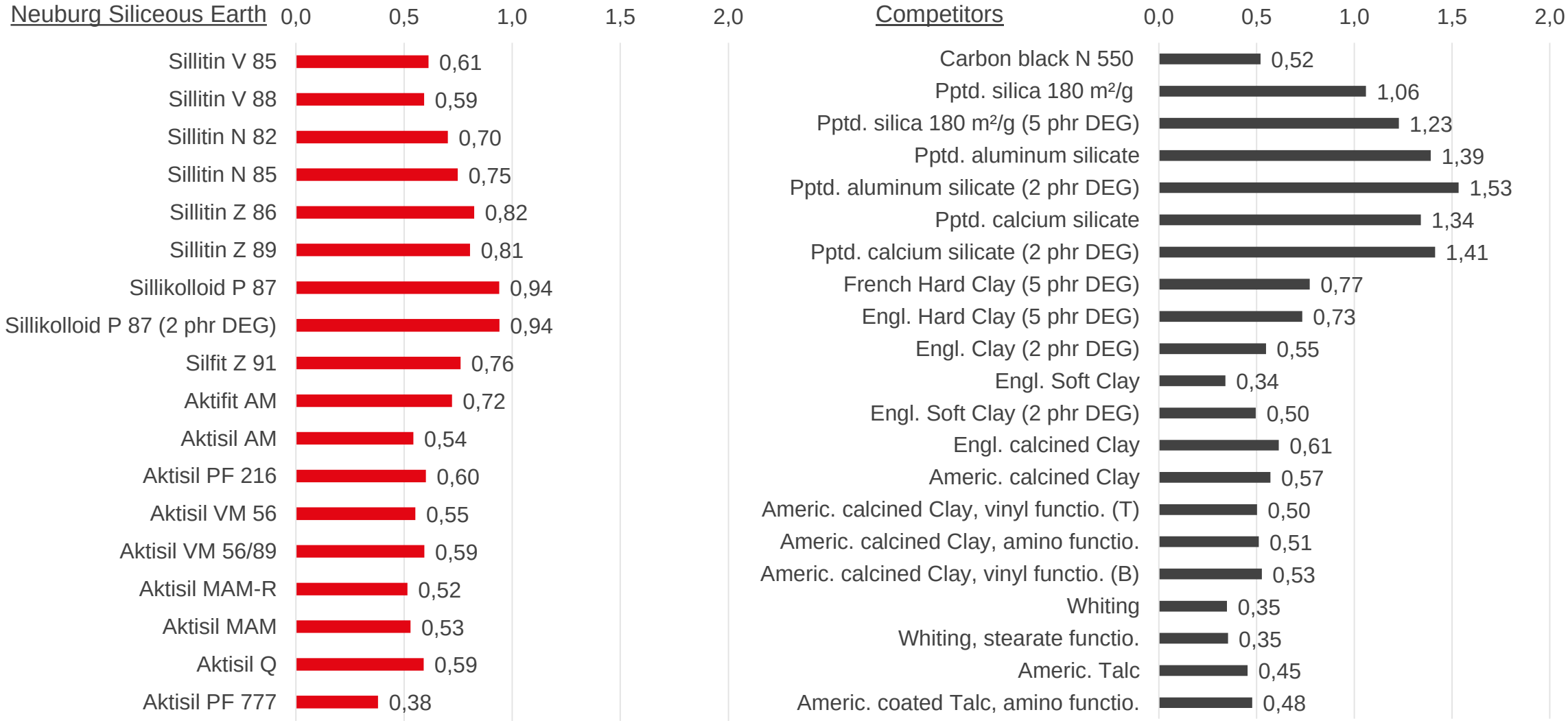
Rotorless curemeter, 180 °C
Torque minimum in Nm





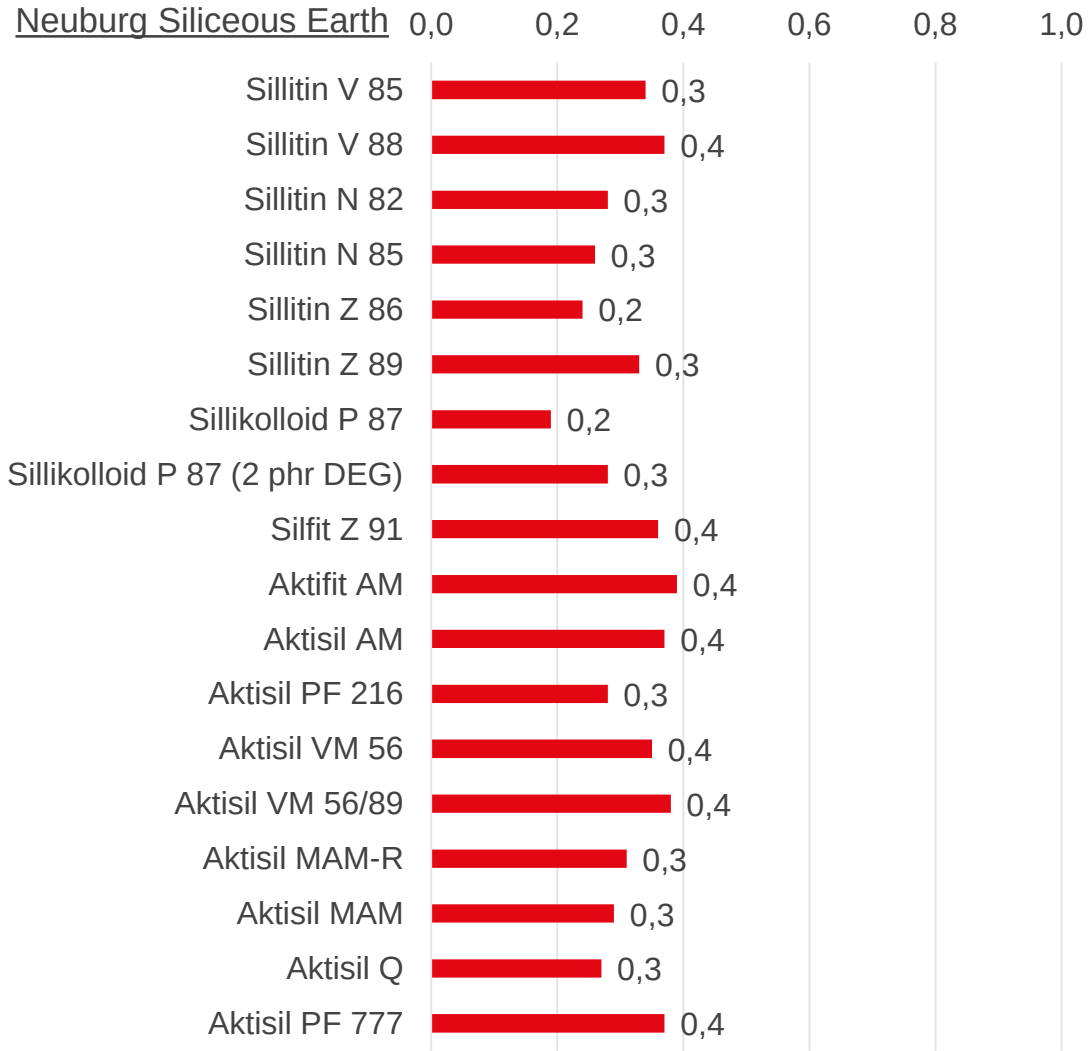
Note: Sillitin N 82 will be replaced by Sillitin N 75

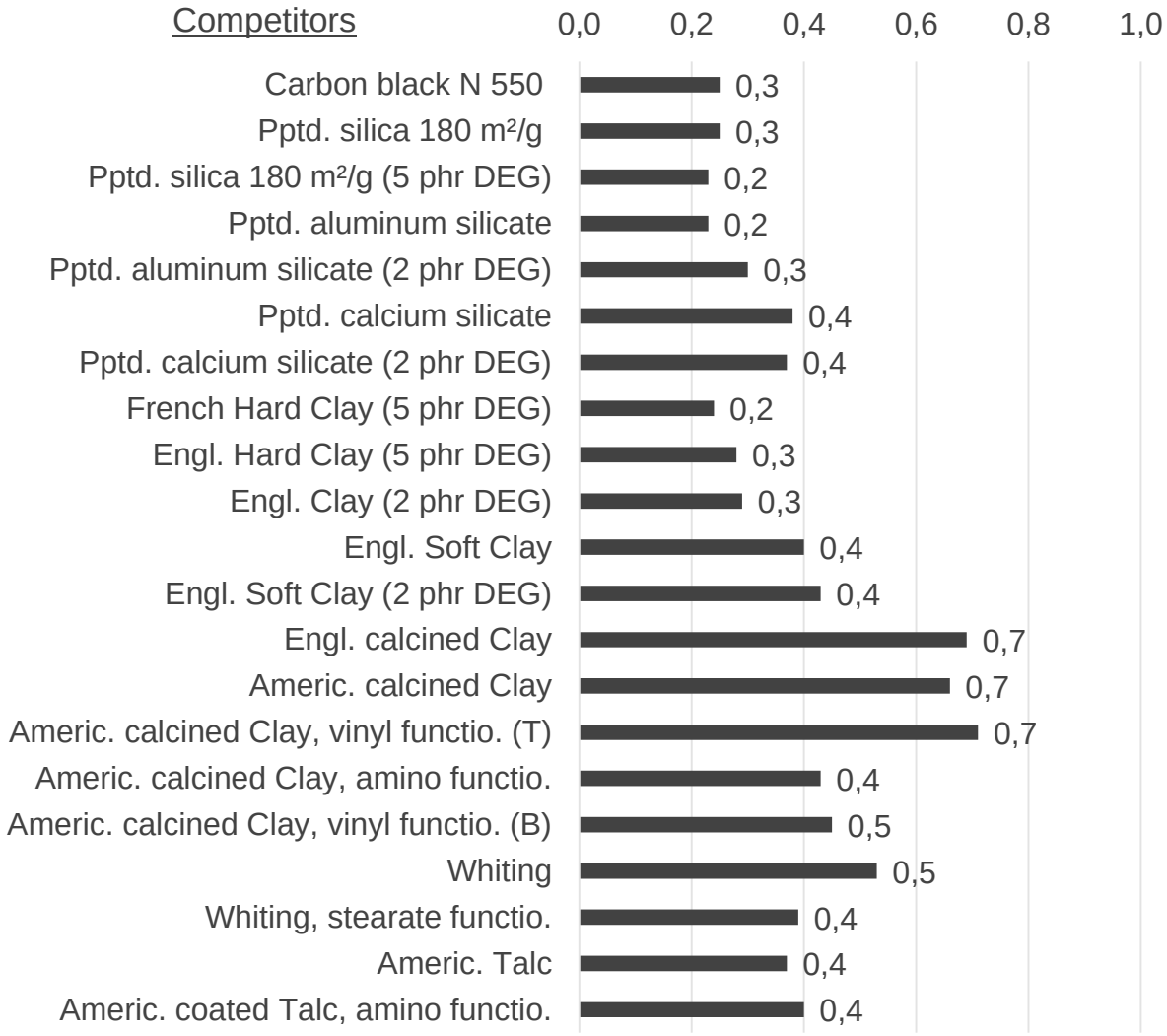
Rotorless curemeter, 180 °C
Cure yield in Nm



Note: Sillitin N 82 will be replaced by Sillitin N 75

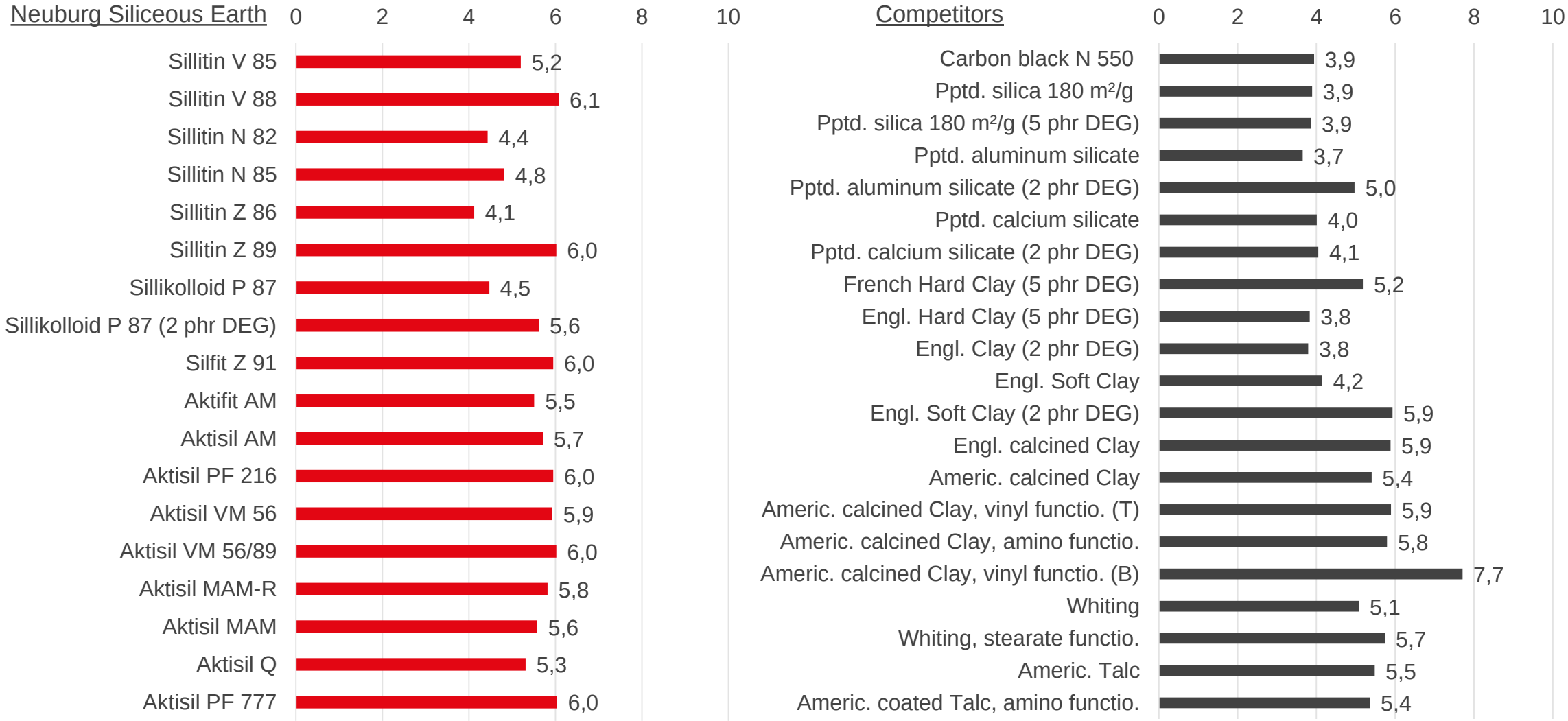
Rotorless curemeter, 180 °C
Conversion time t_5 in min.





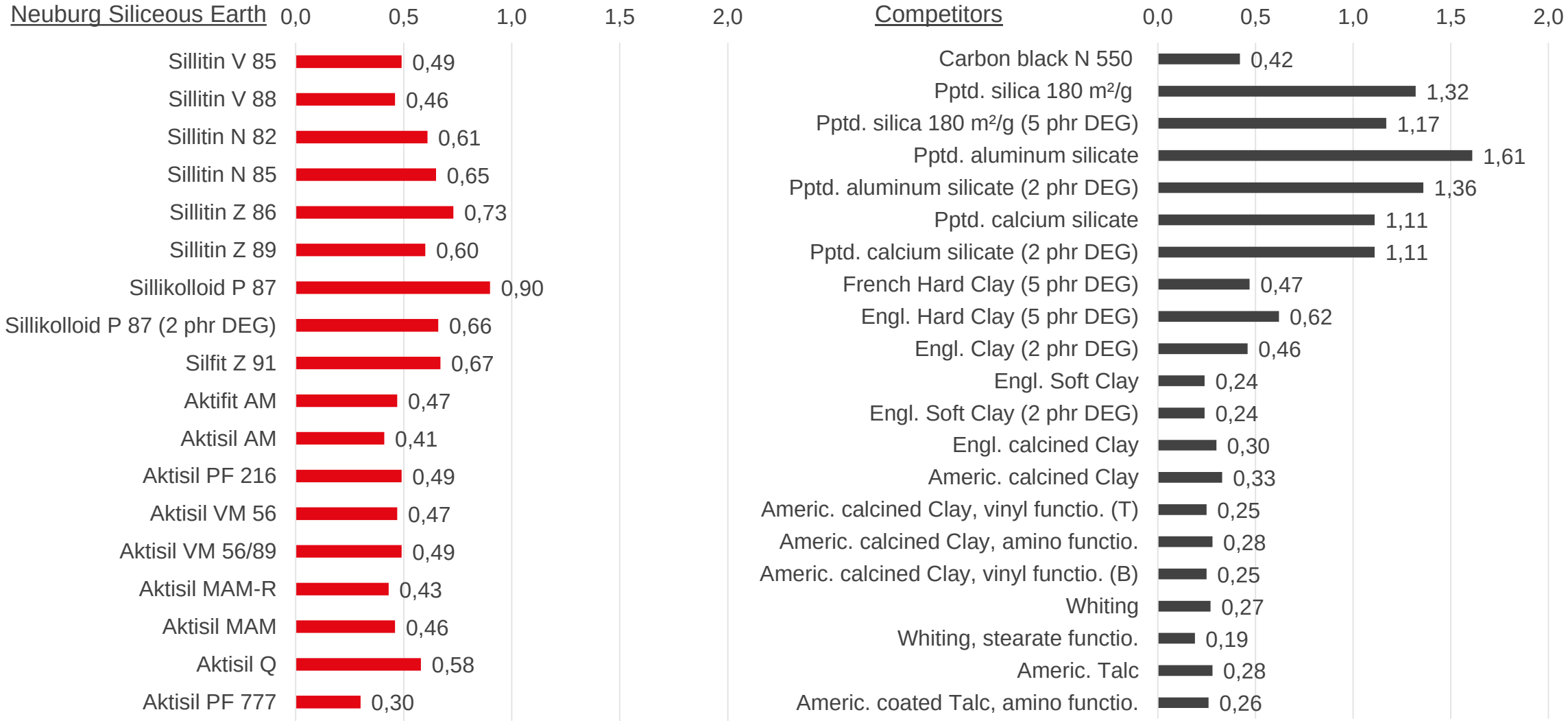
Note: Sillitin N 82 will be replaced by Sillitin N 75

Rotorless curemeter, 180 °C
Conversion time t_{90} in min.



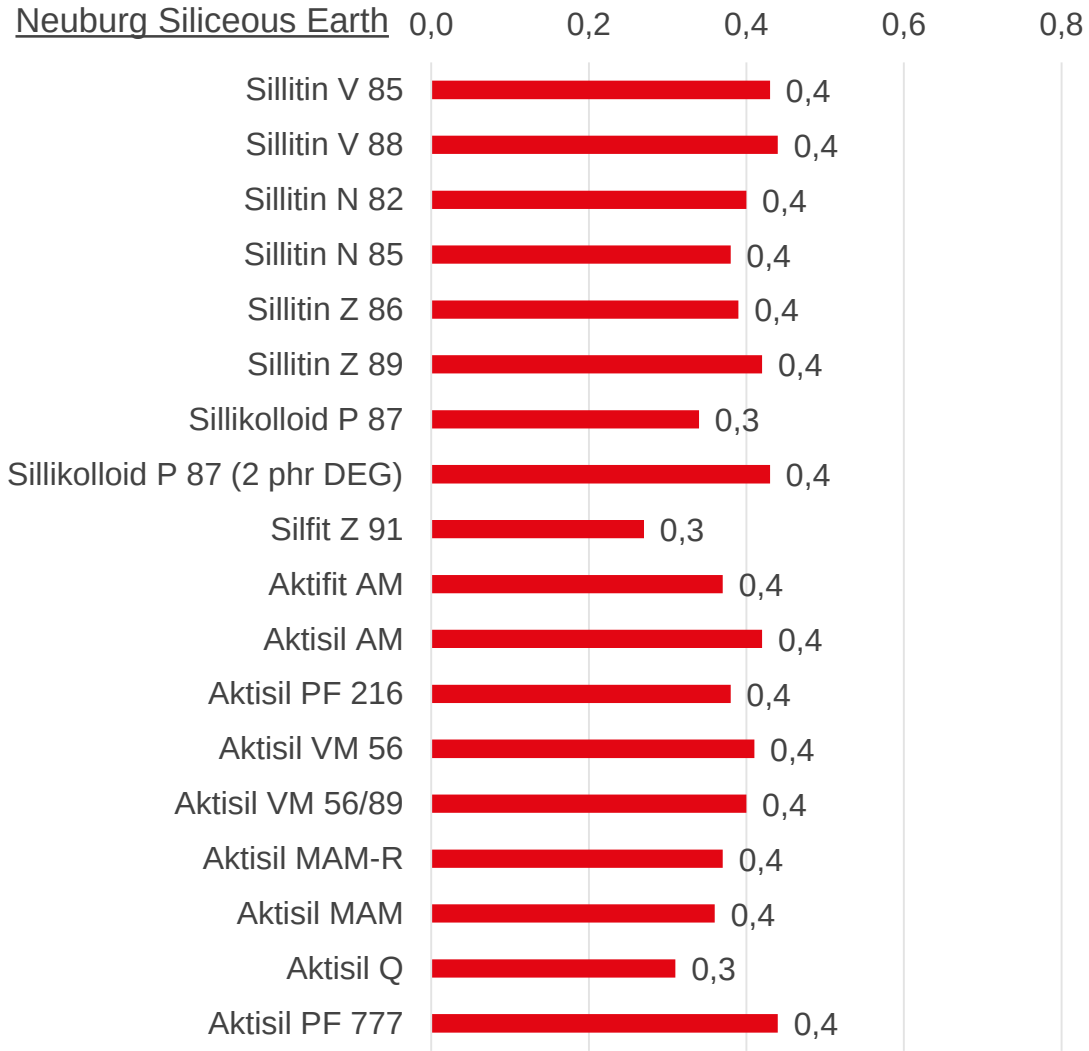
Note: Sillitin N 82 will be replaced by Sillitin N 75

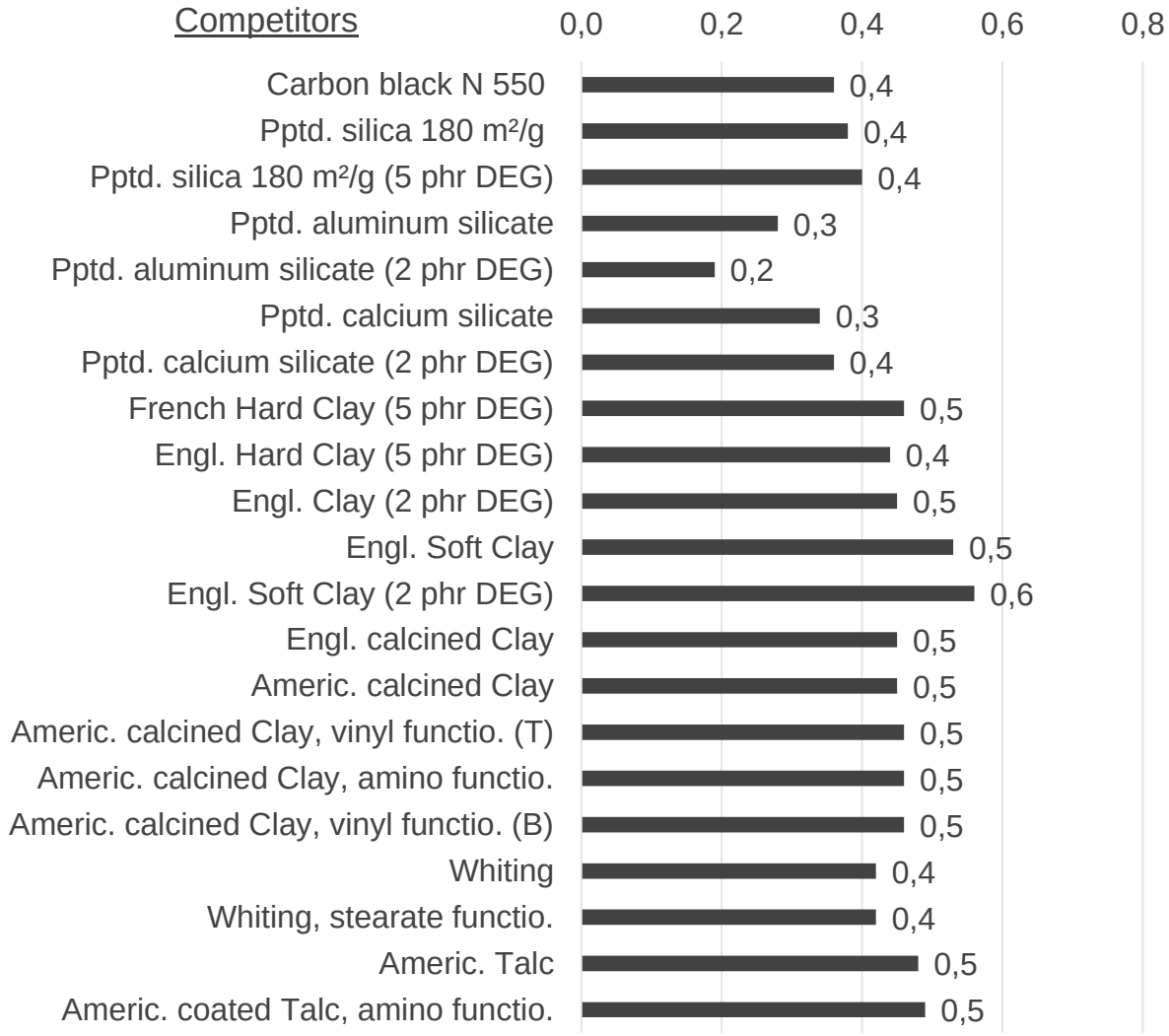
Rotorless curemeter, 180 °C
Max. speed of cure in Nm/min.



Note: Sillitin N 82 will be replaced by Sillitin N 75

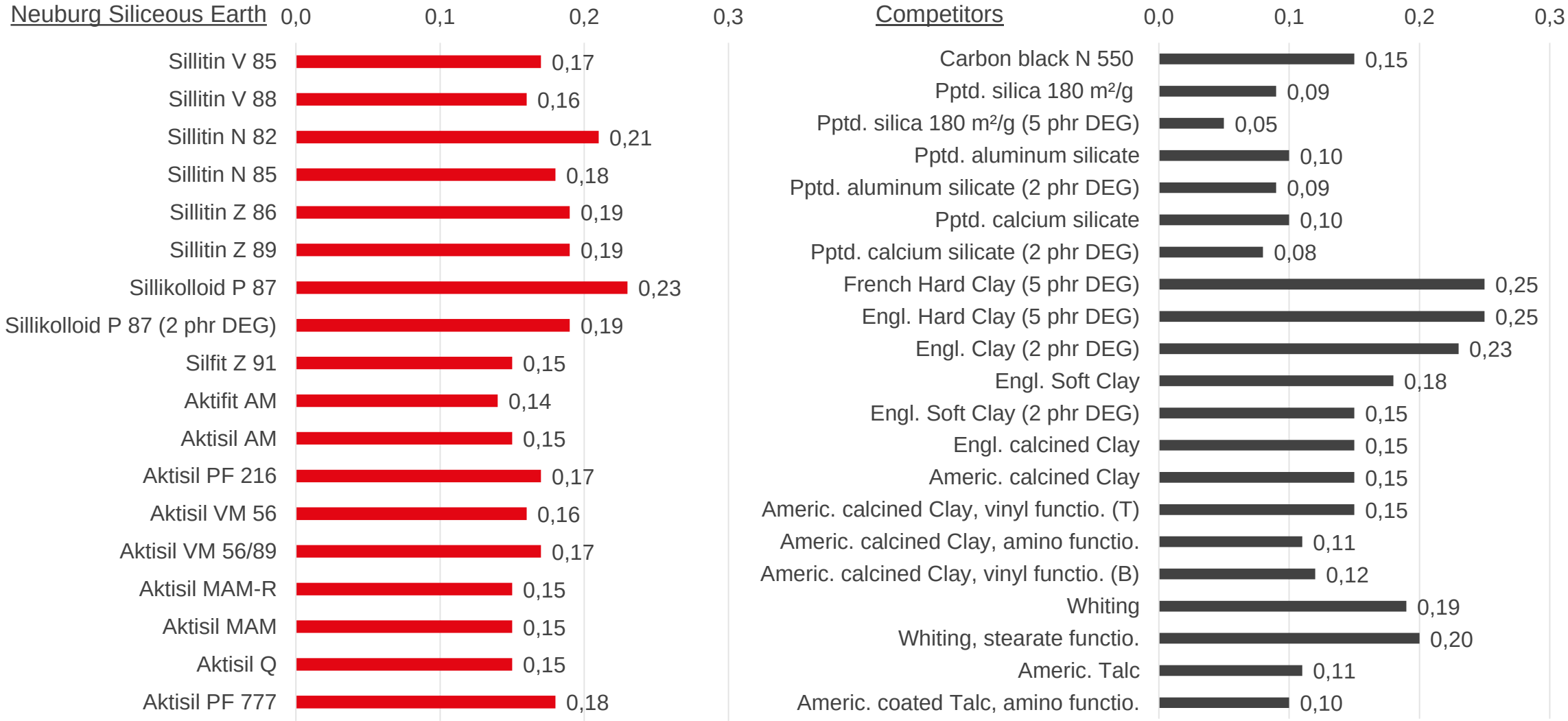
Rotorless curemeter, 180 °C
Time until max. speed of cure in min.





Note: Sillitin N 82 will be replaced by Sillitin N 75

Rotorless curemeter, 180 °C
tan δ, end of test



Note: Sillitin N 82 will be replaced by Sillitin N 75

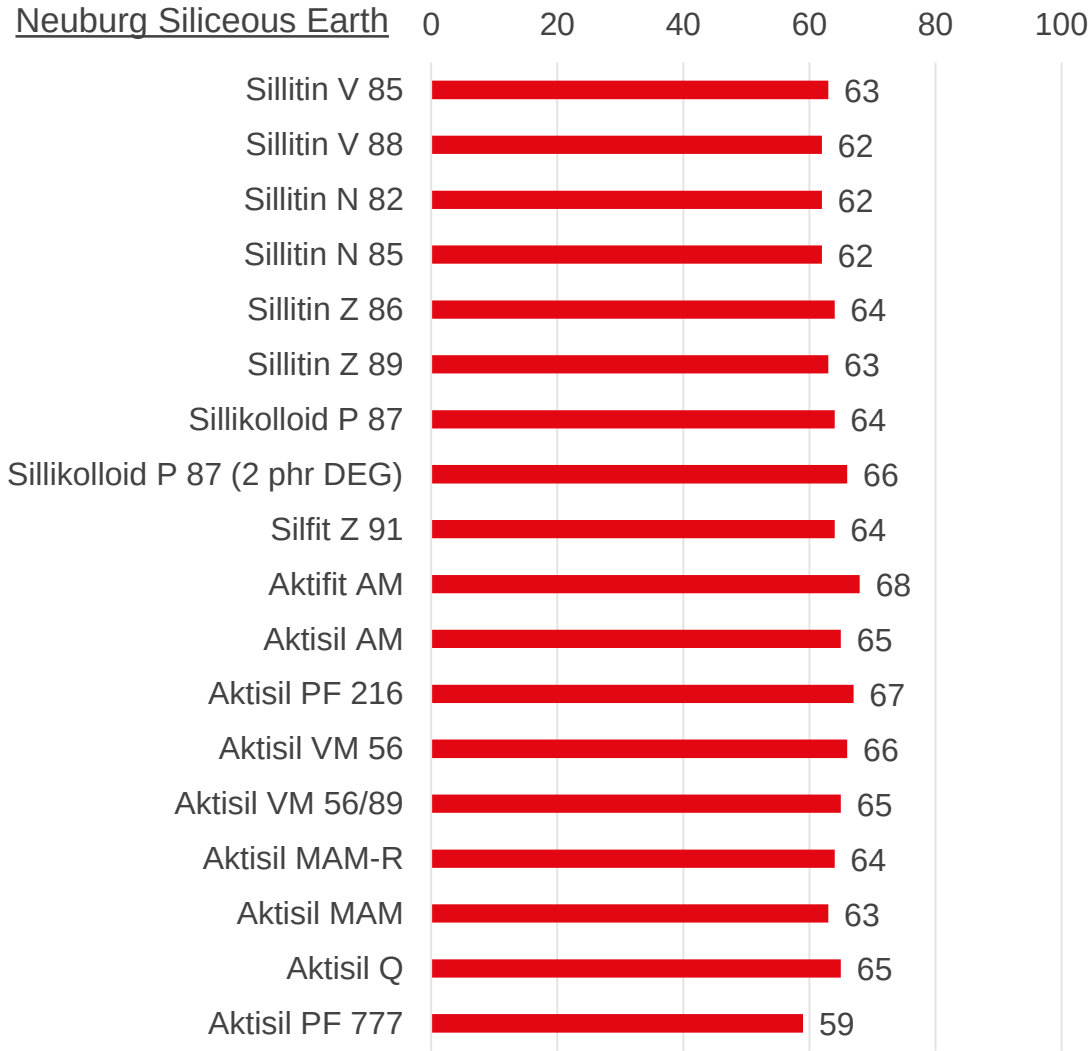
→ back to results

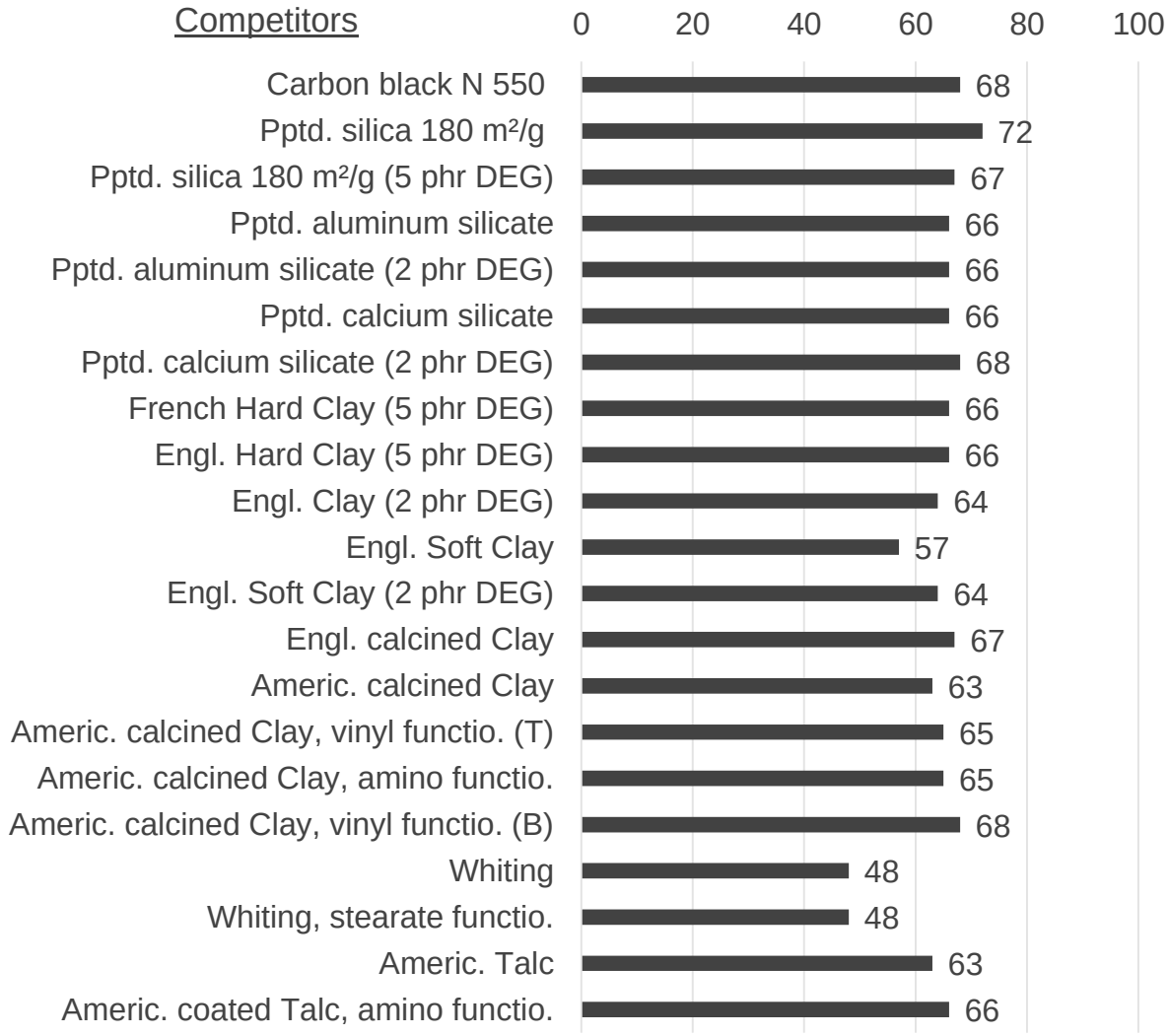
Properties of vulcanizate

HOFFMANN MINERAL®
We supply materials for good ideas

Hardness – piled-up S2 dumbbells

DIN ISO 7619-1

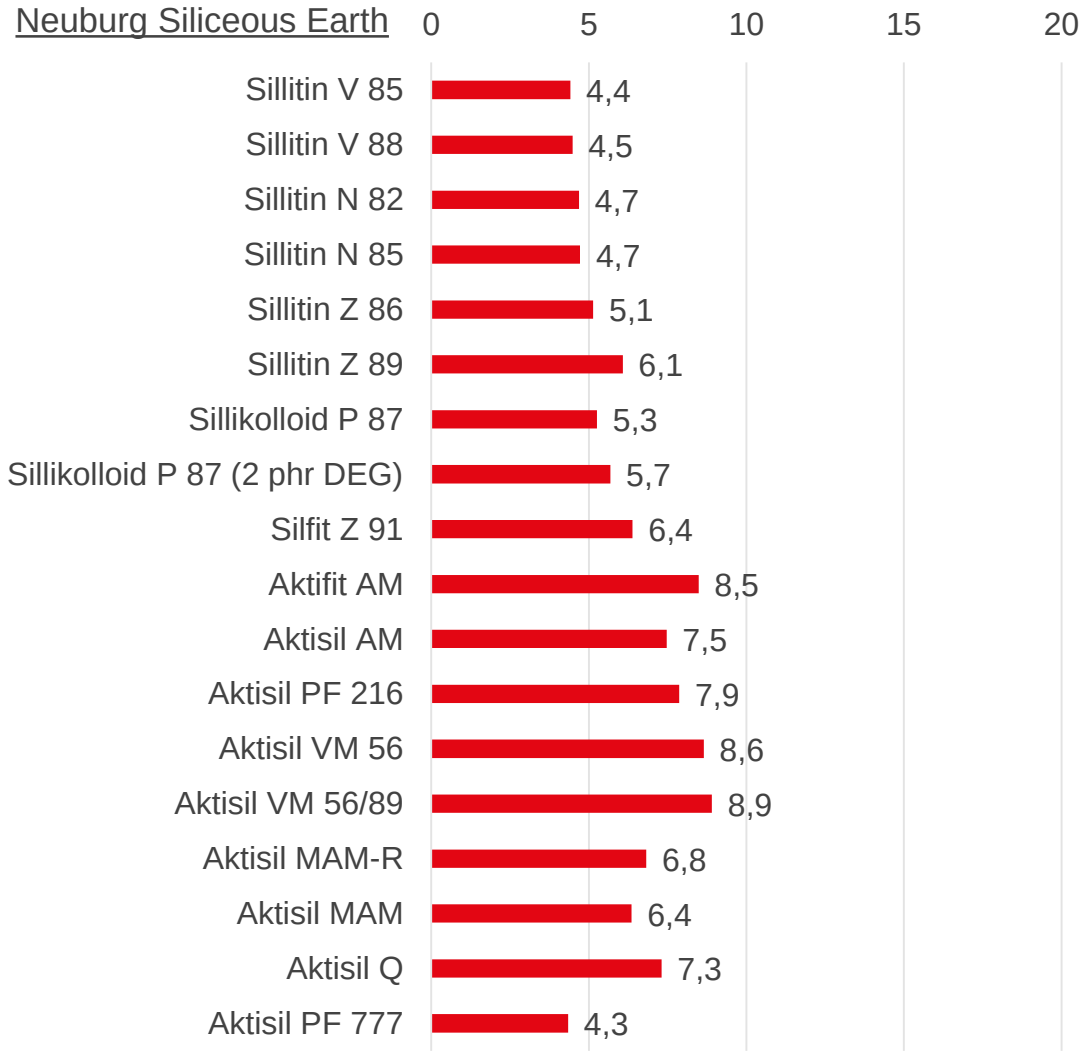


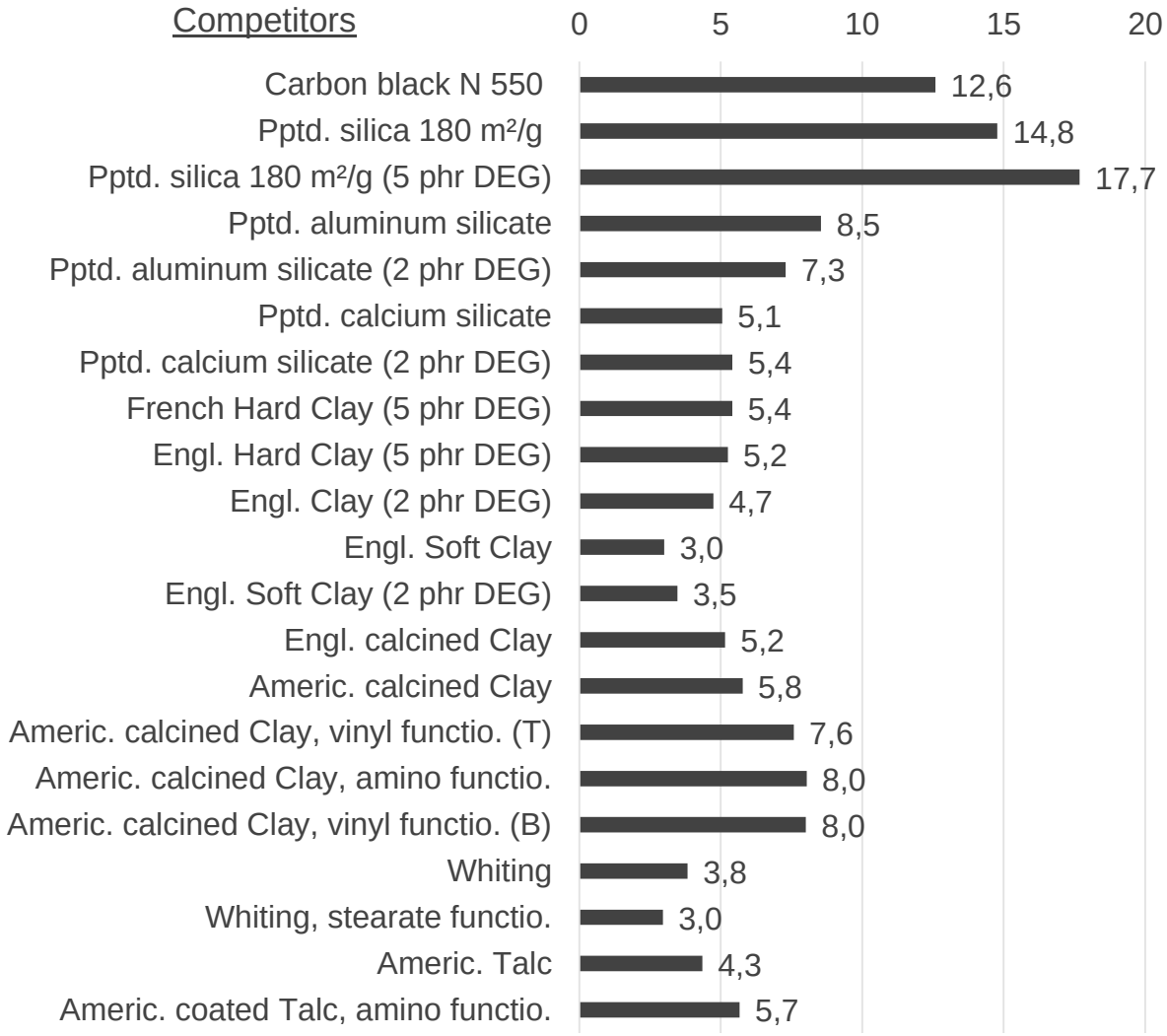


Note: Sillitin N 82 will be replaced by Sillitin N 75

Tensile strength in MPa

DIN 53 504, S2

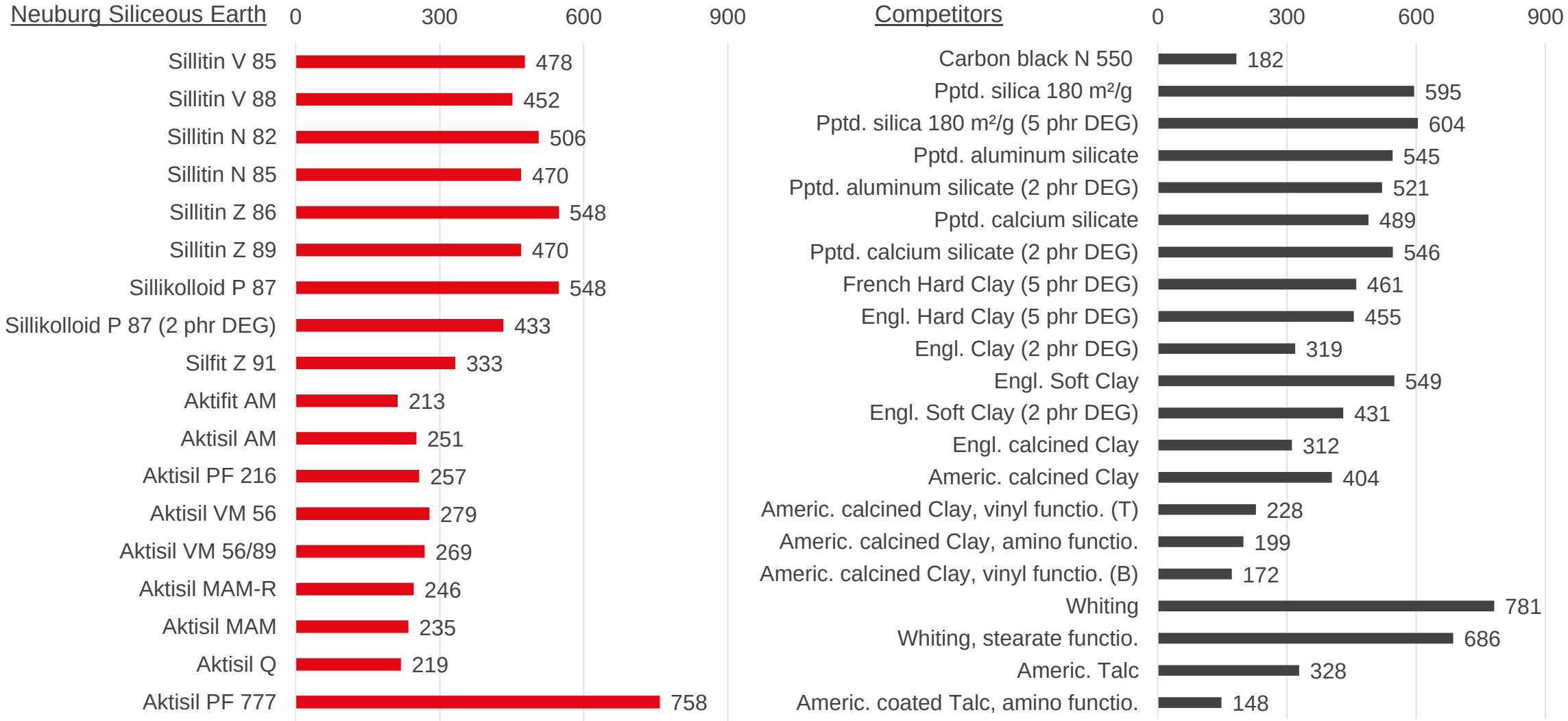




Note: Sillitin N 82 will be replaced by Sillitin N 75

Elongation at break in %

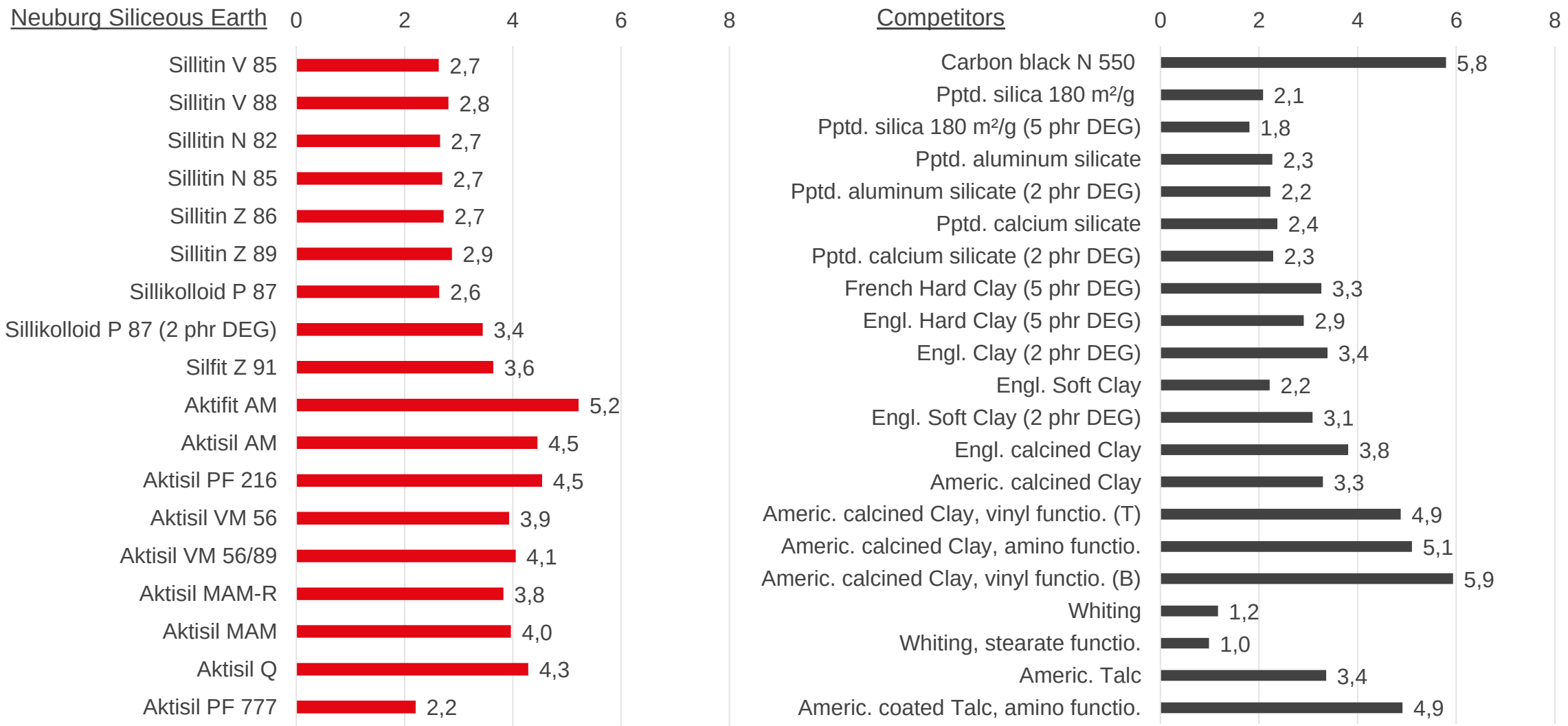
DIN 53 504, S2



Note: Sillitin N 82 will be replaced by Sillitin N 75

Modulus 100 % in MPa

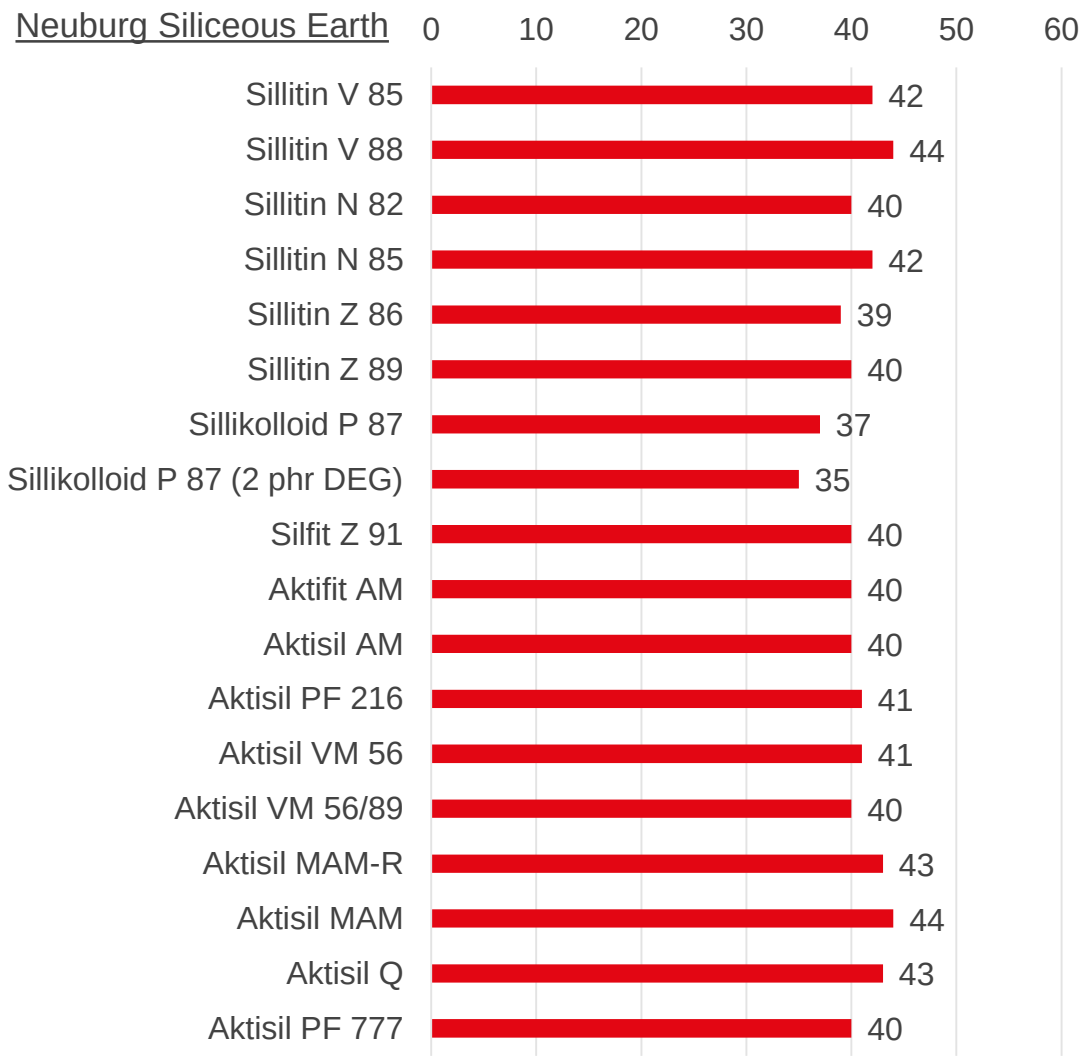
DIN 53 504, S2

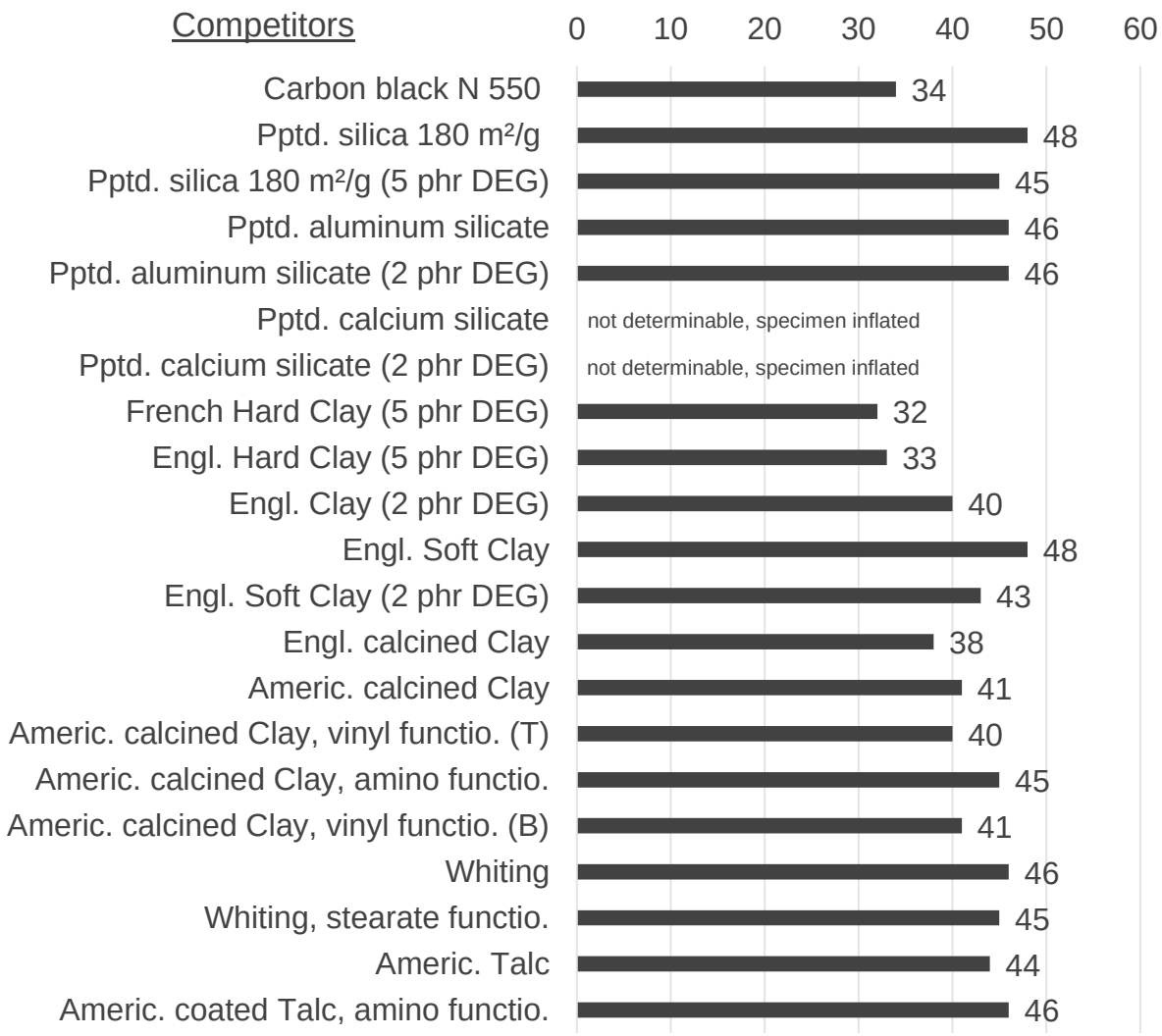


Note: Sillitin N 82 will be replaced by Sillitin N 75

Rebound elasticity in %

DIN 53 512

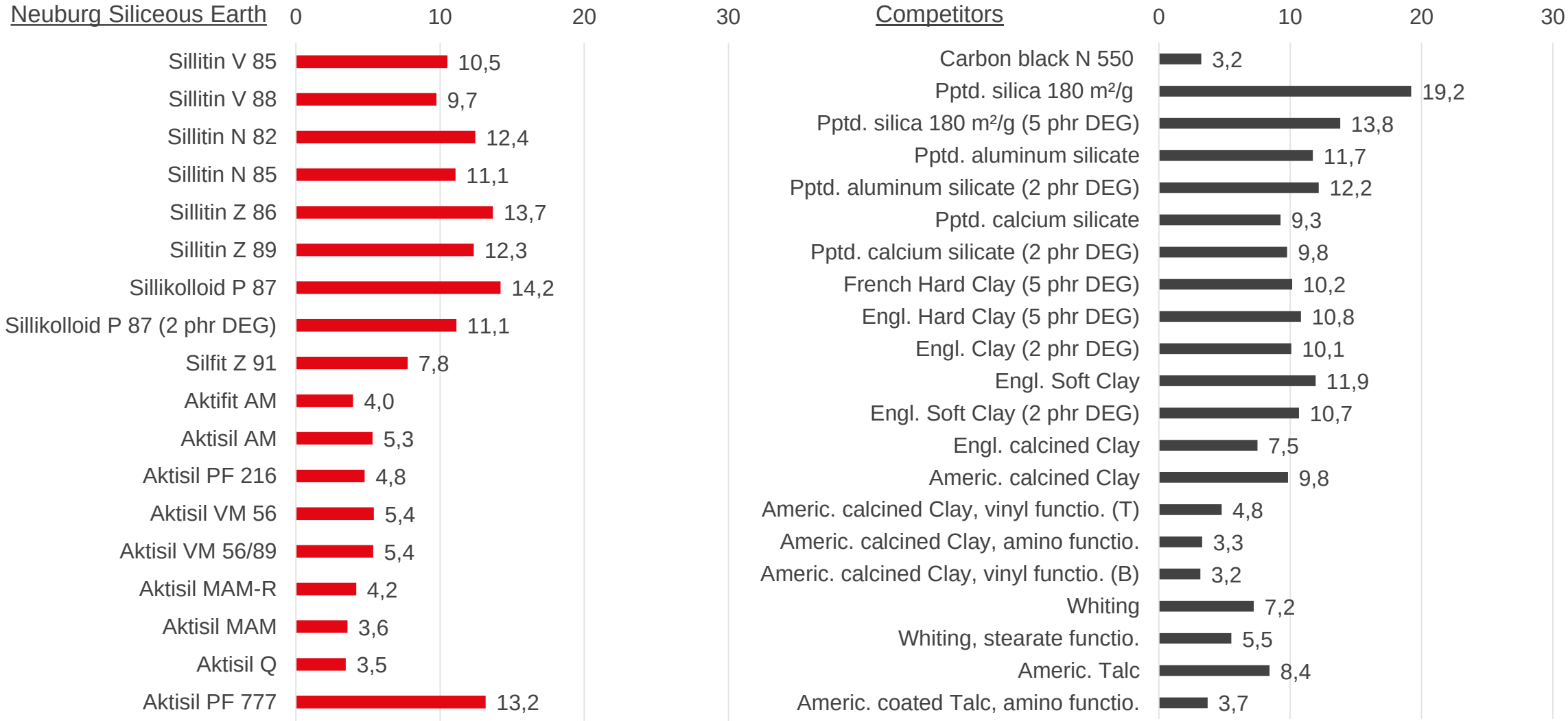




Note: Sillitin N 82 will be replaced by Sillitin N 75

Tear resistance in N/mm – Trousers specimen

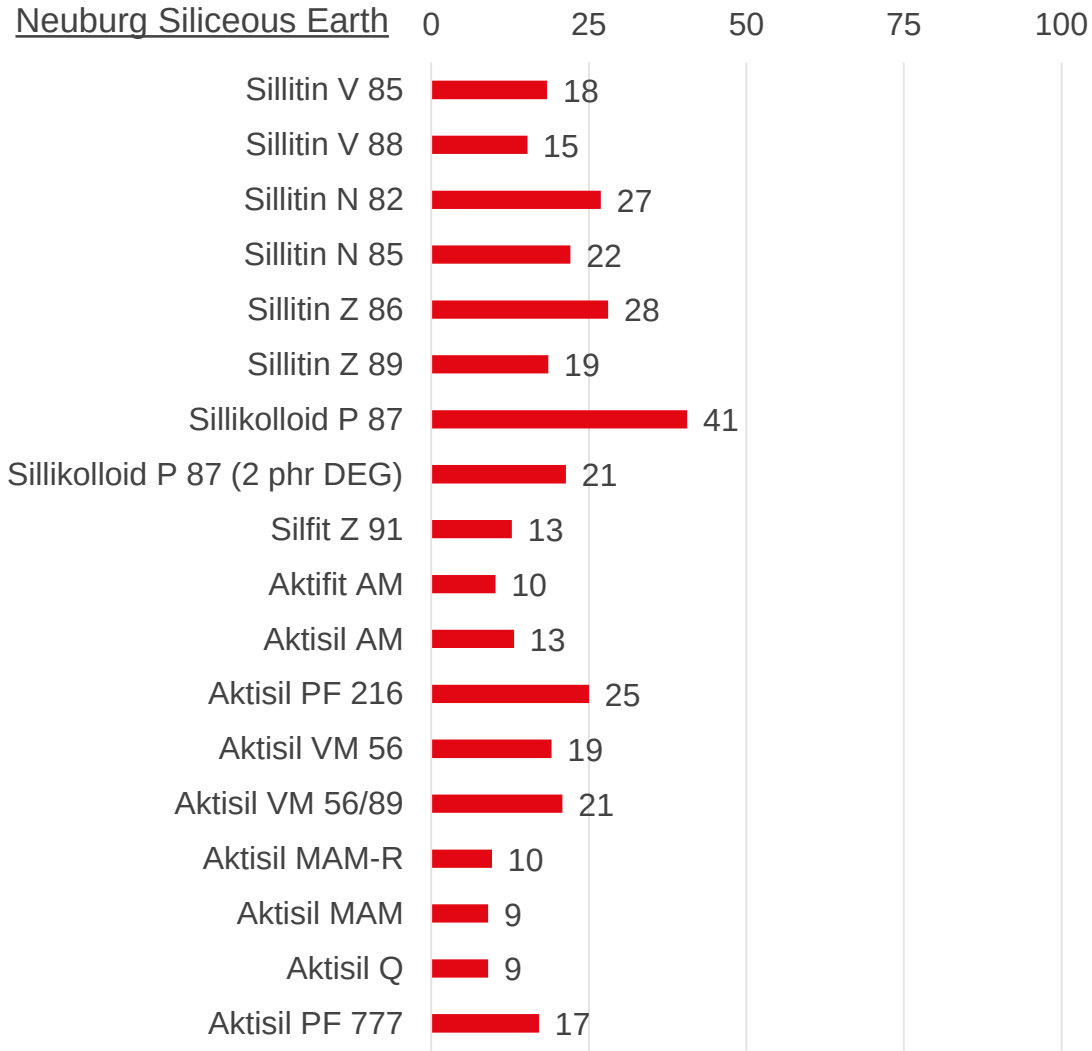
DIN ISO 34-1, A

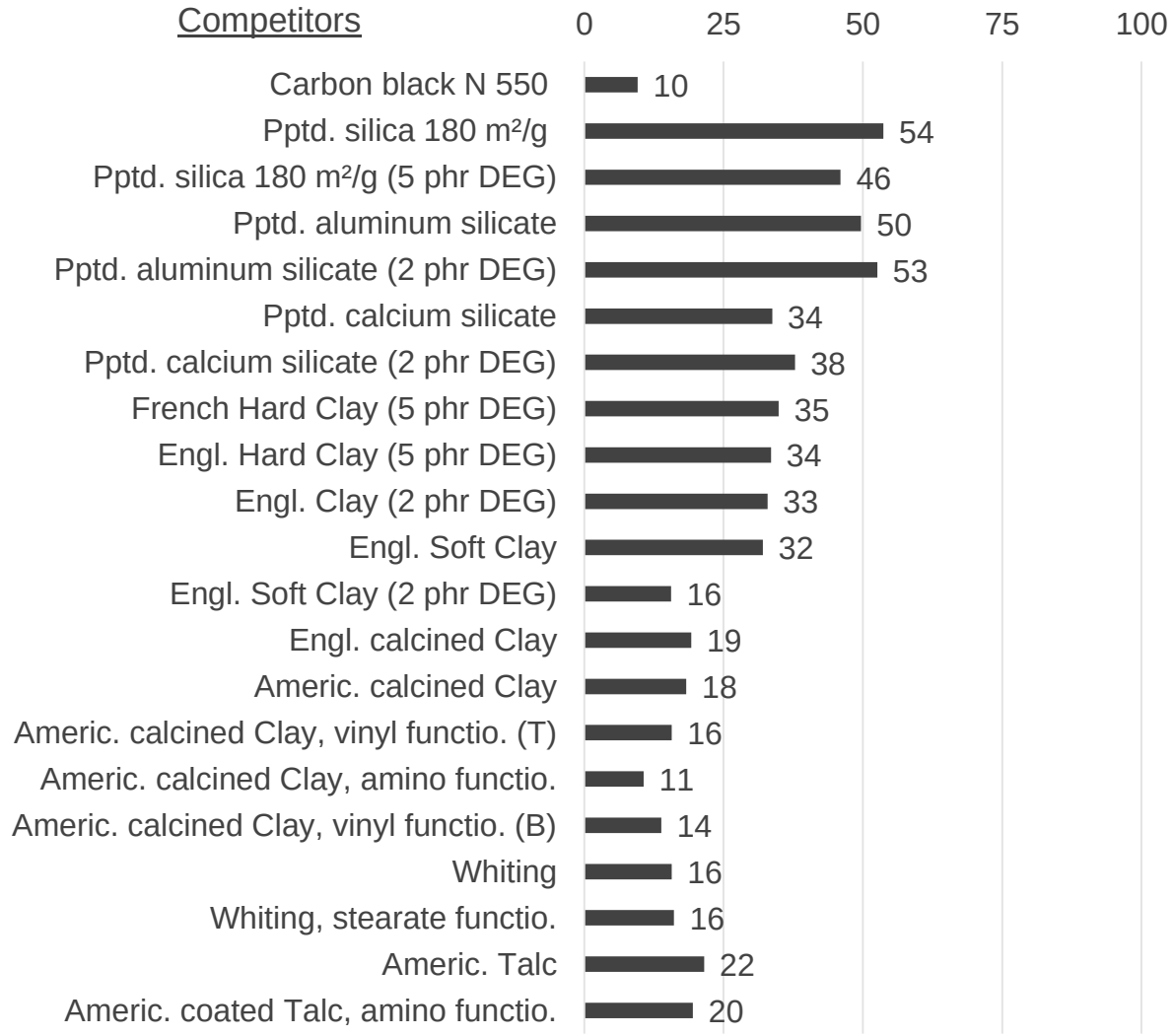


Note: Sillitin N 82 will be replaced by Sillitin N 75

Compression set in % (24 h / 100 °C / 25 % Def.)

DIN ISO 815-1, Type B

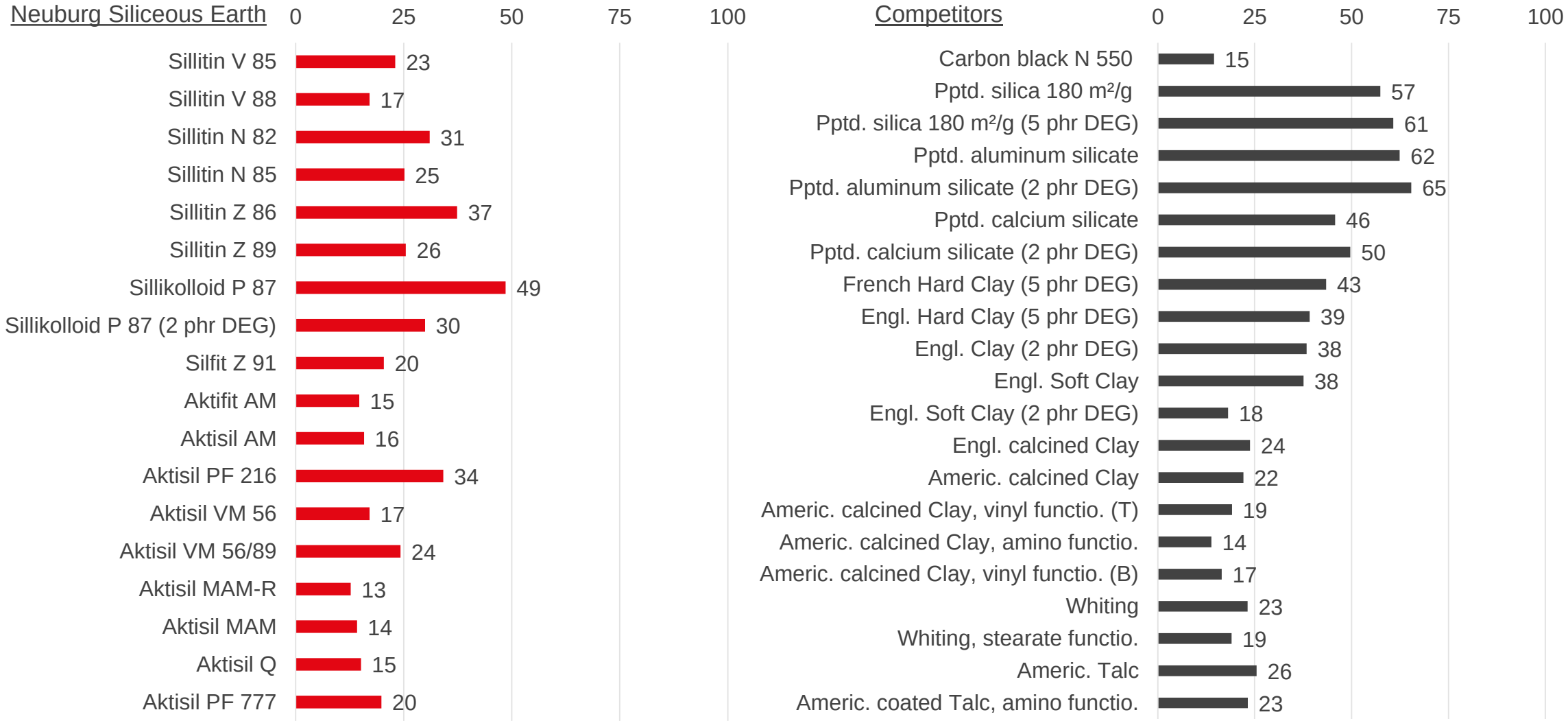




Note: Sillitin N 82 will be replaced by Sillitin N 75

Compression set in % (24 h / 125 °C / 25 % Def.)

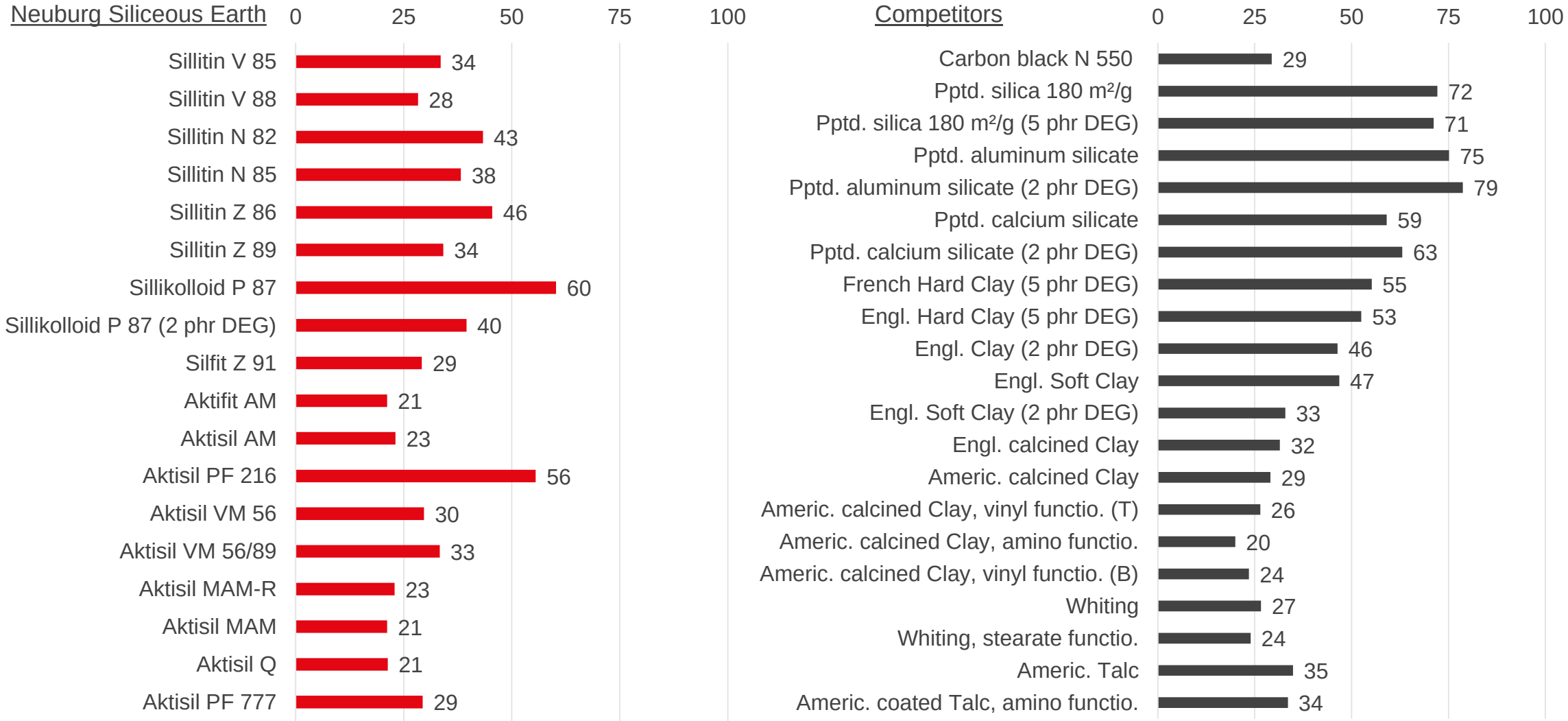
DIN ISO 815-1, Type B



Note: Sillitin N 82 will be replaced by Sillitin N 75

Compression set in % (24 h / 150 °C / 25 % Def.)

DIN ISO 815-1, Type B



Note: Sillitin N 82 will be replaced by Sillitin N 75

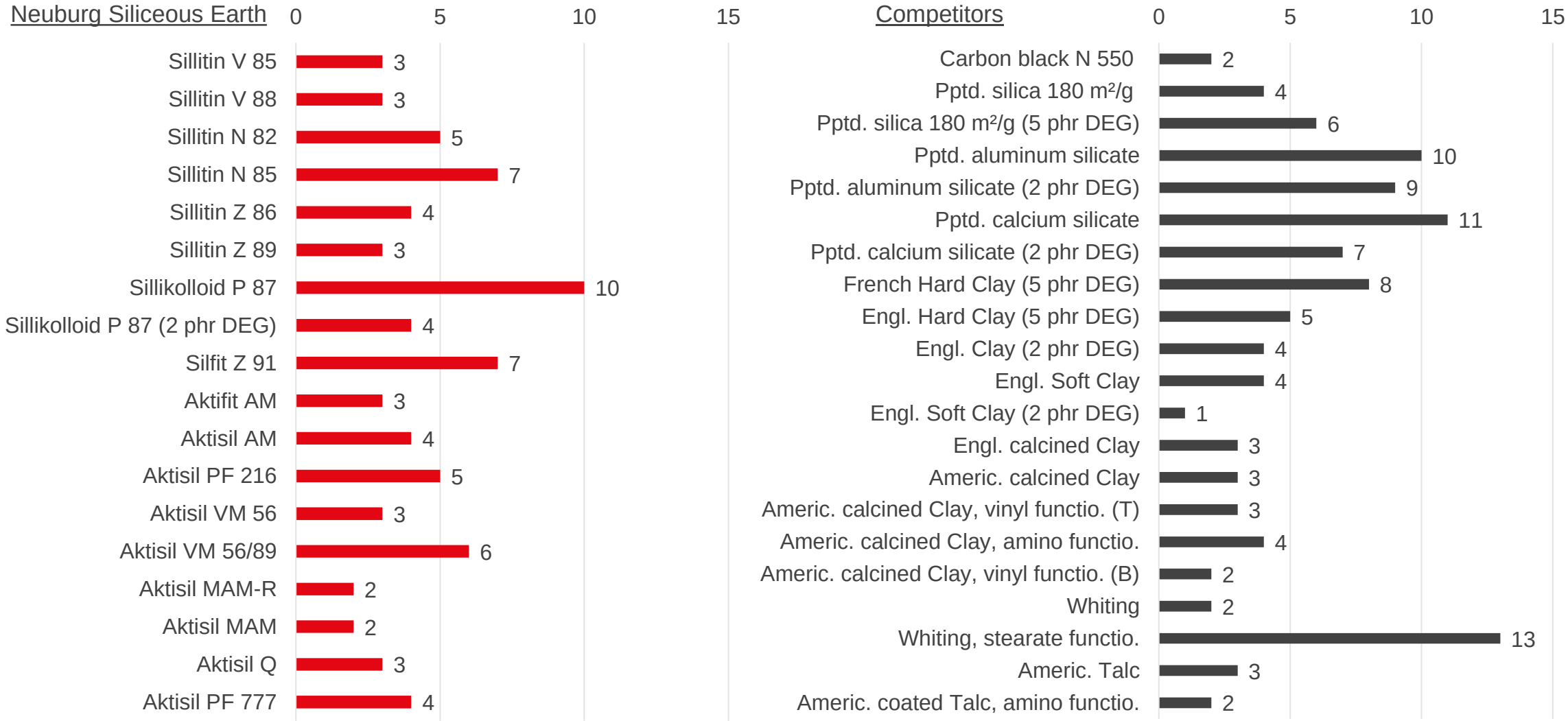
→ back to results

Hot air aging 168 h / 100 °C

ISO 188, D

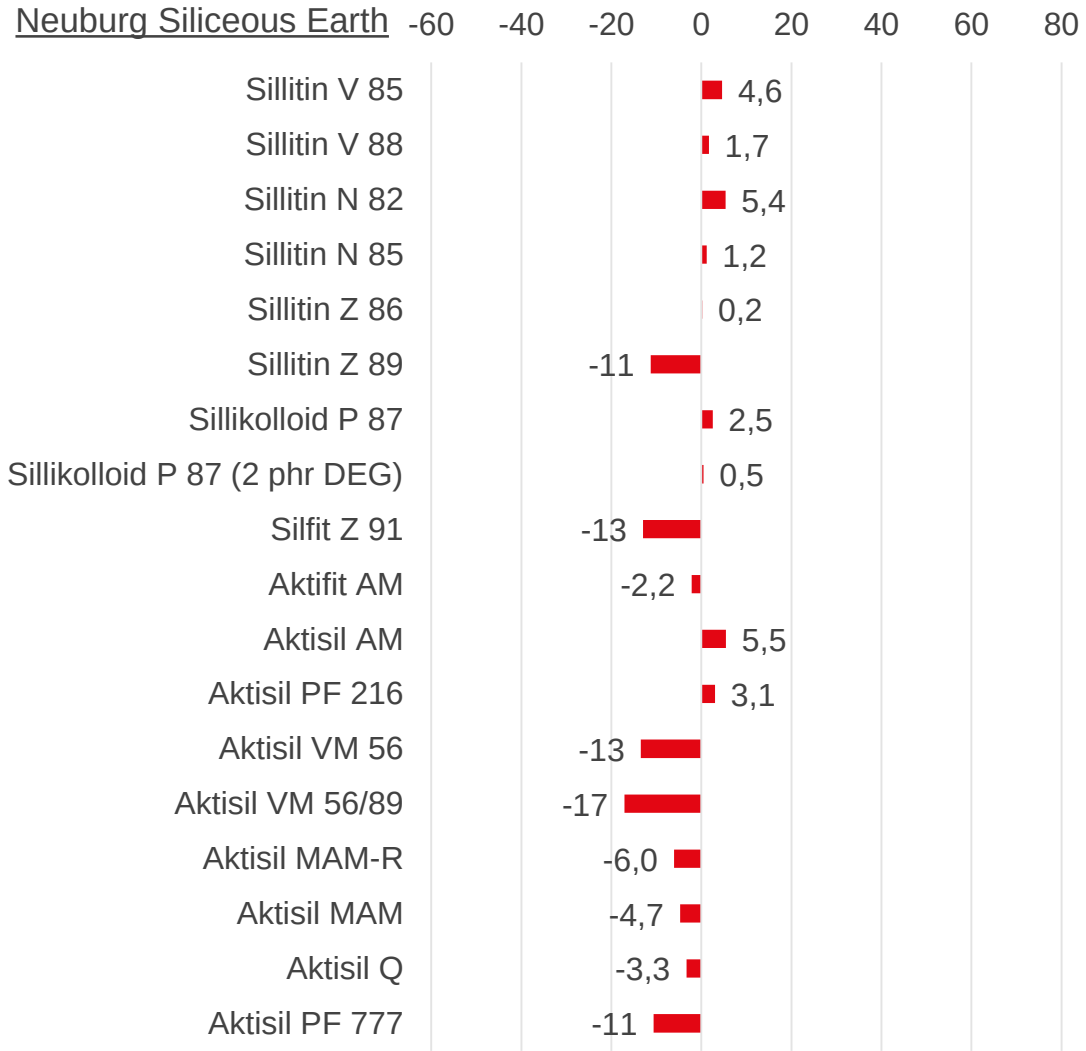
HOFFMANN MINERAL®
We supply materials for good ideas

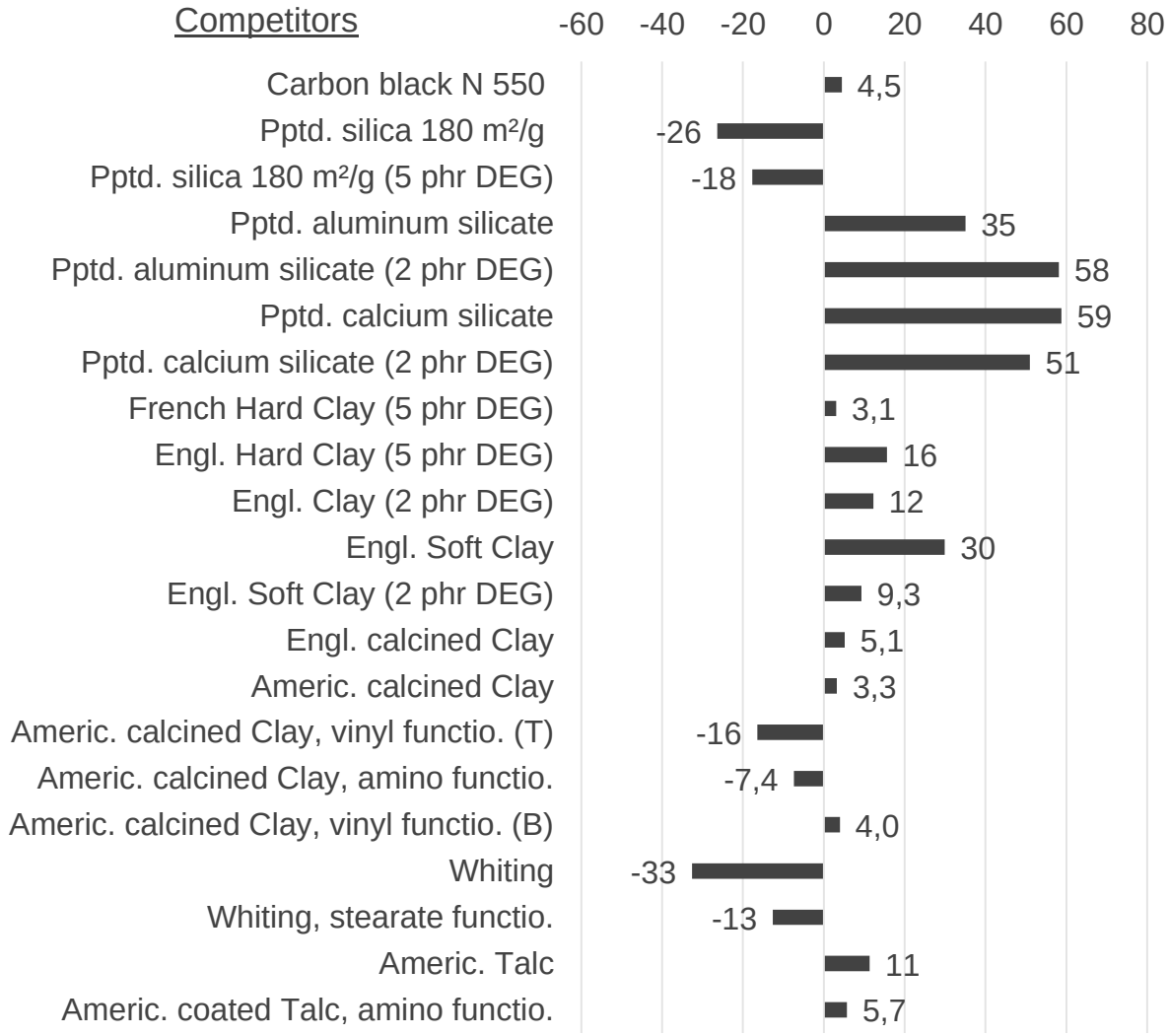
Hot air aging 168 h / 100 °C
Change of hardness in Shore A – piled up S2 dumbbells



Note: Sillitin N 82 will be replaced by Sillitin N 75

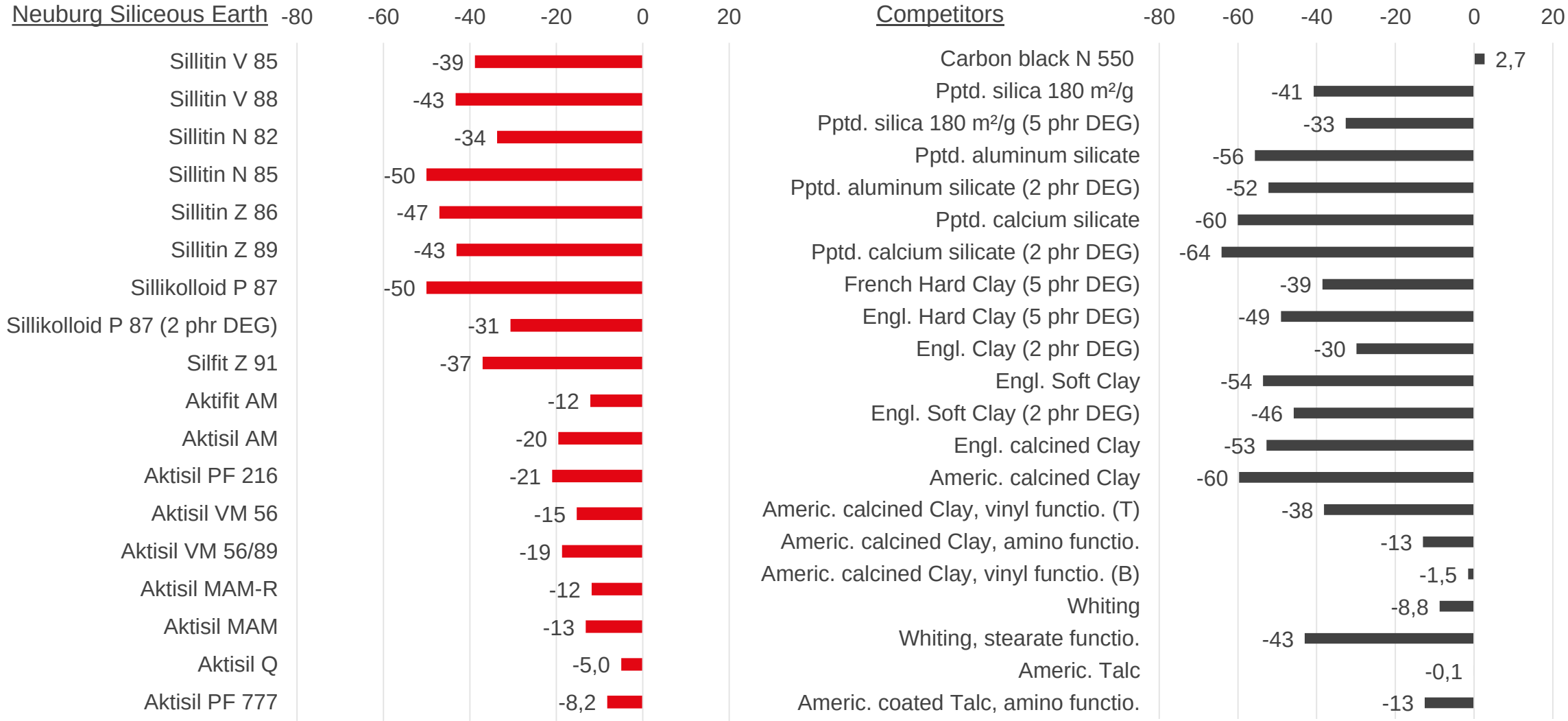
Hot air aging 168 h / 100 °C
Change of tensile strength in %





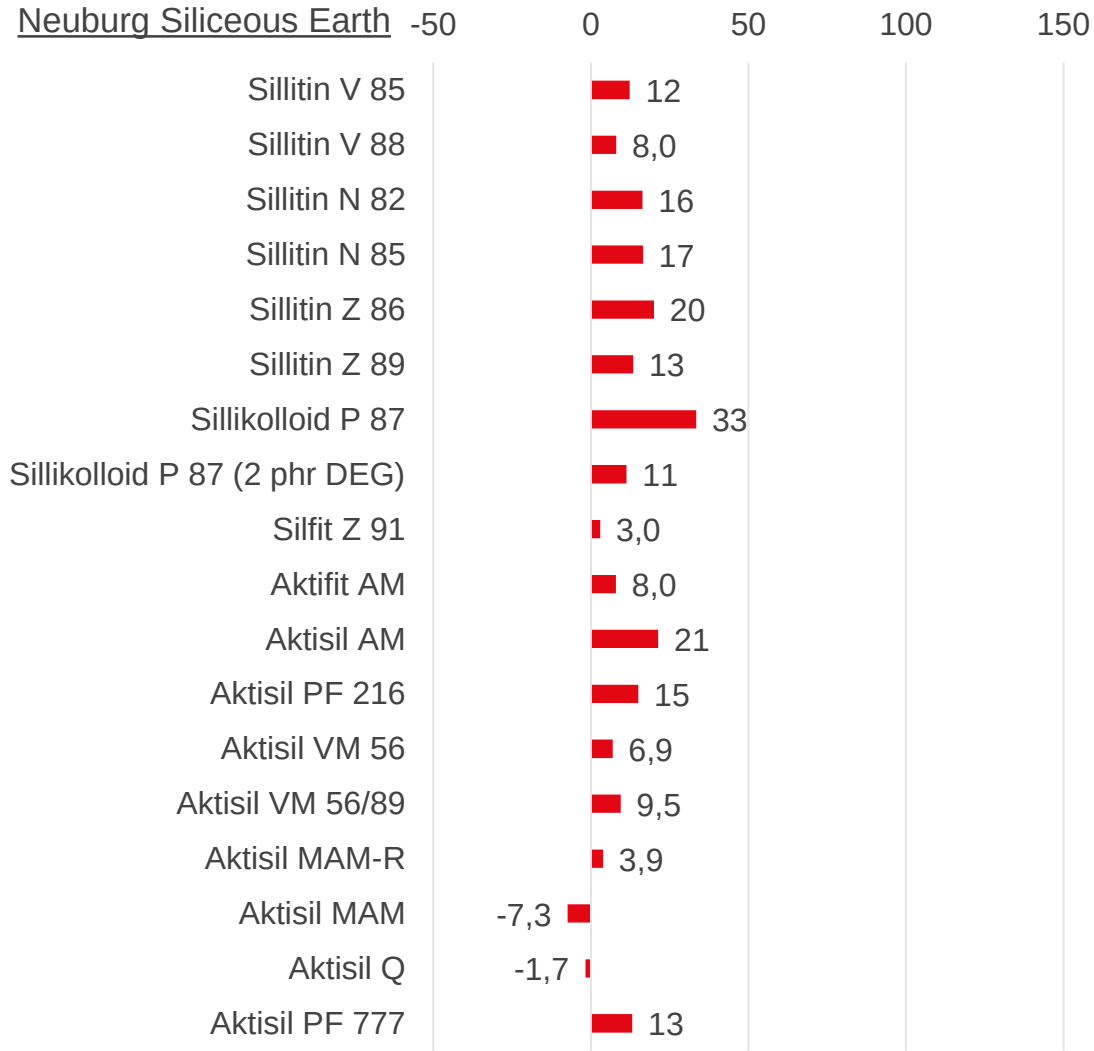
Note: Sillitin N 82 will be replaced by Sillitin N 75

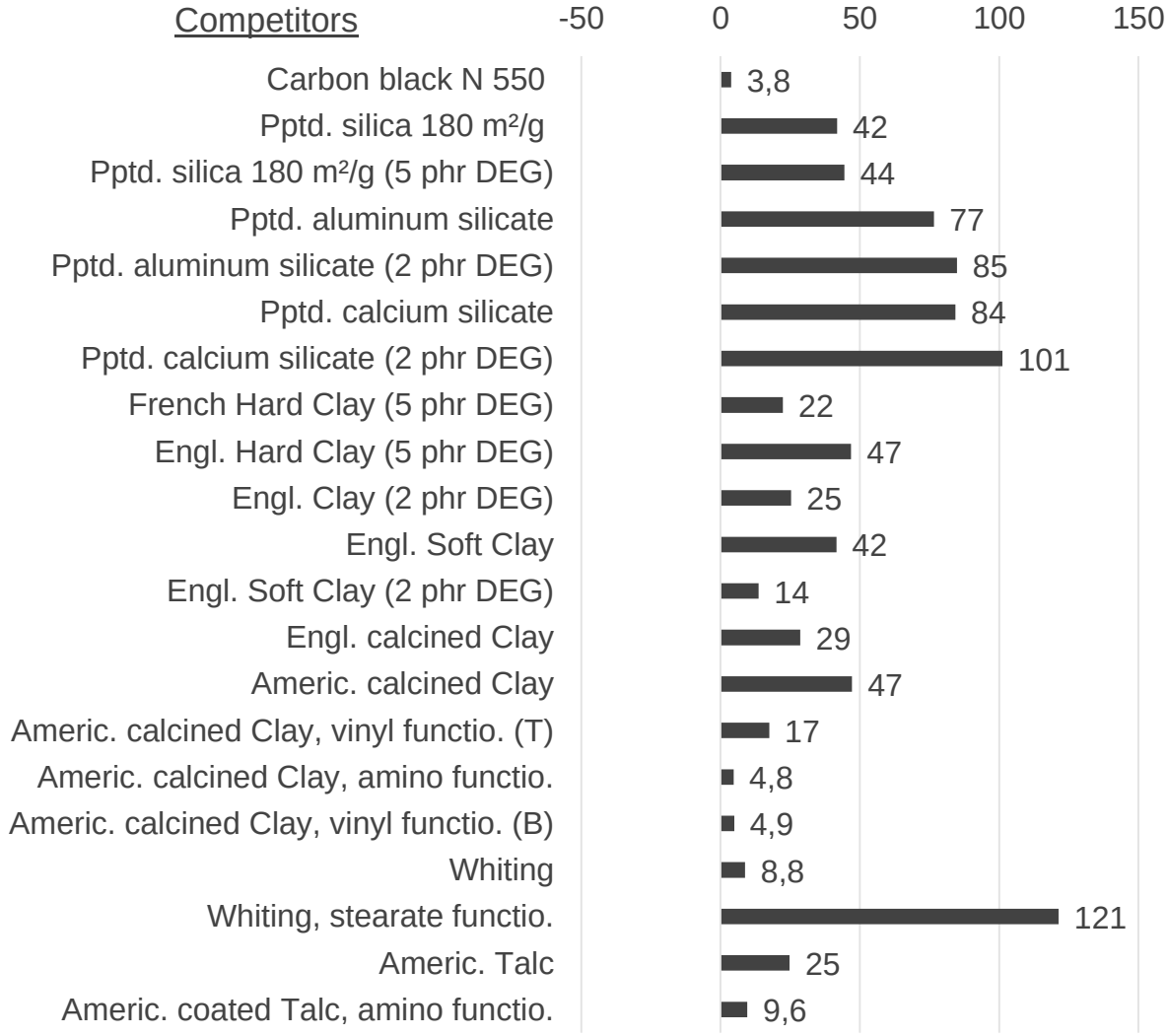
Hot air aging 168 h / 100 °C
Change of elongation at break in rel.%



Note: Sillitin N 82 will be replaced by Sillitin N 75

Hot air aging 168 h / 100 °C
Change of modulus 100 % in %





Note: Sillitin N 82 will be replaced by Sillitin N 75

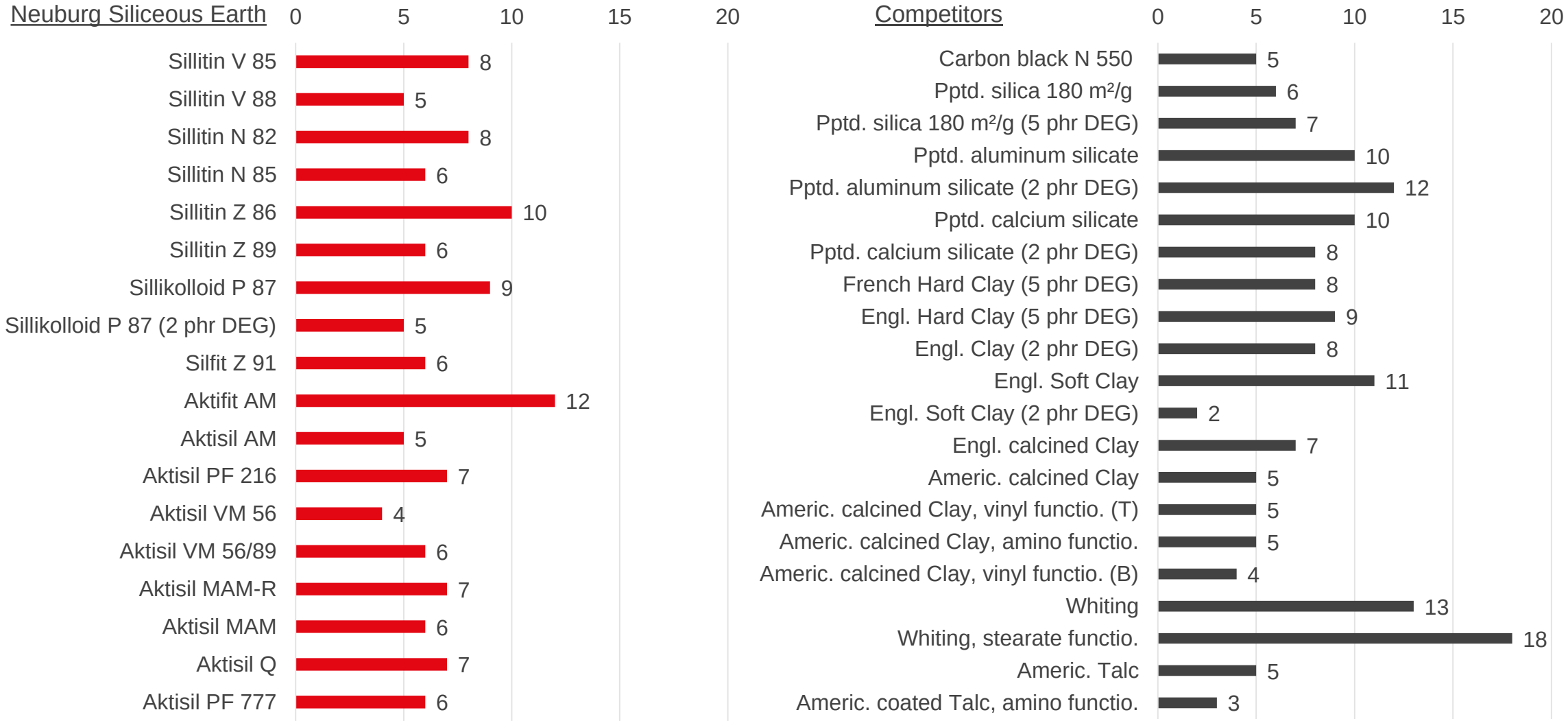
→ back to results

Hot air aging 168 h / 125 °C

ISO 188, D

HOFFMANN MINERAL®
We supply materials for good ideas

Hot air aging 168 h / 125 °C
Change of hardness in Shore A – piled up S2 dumbbells

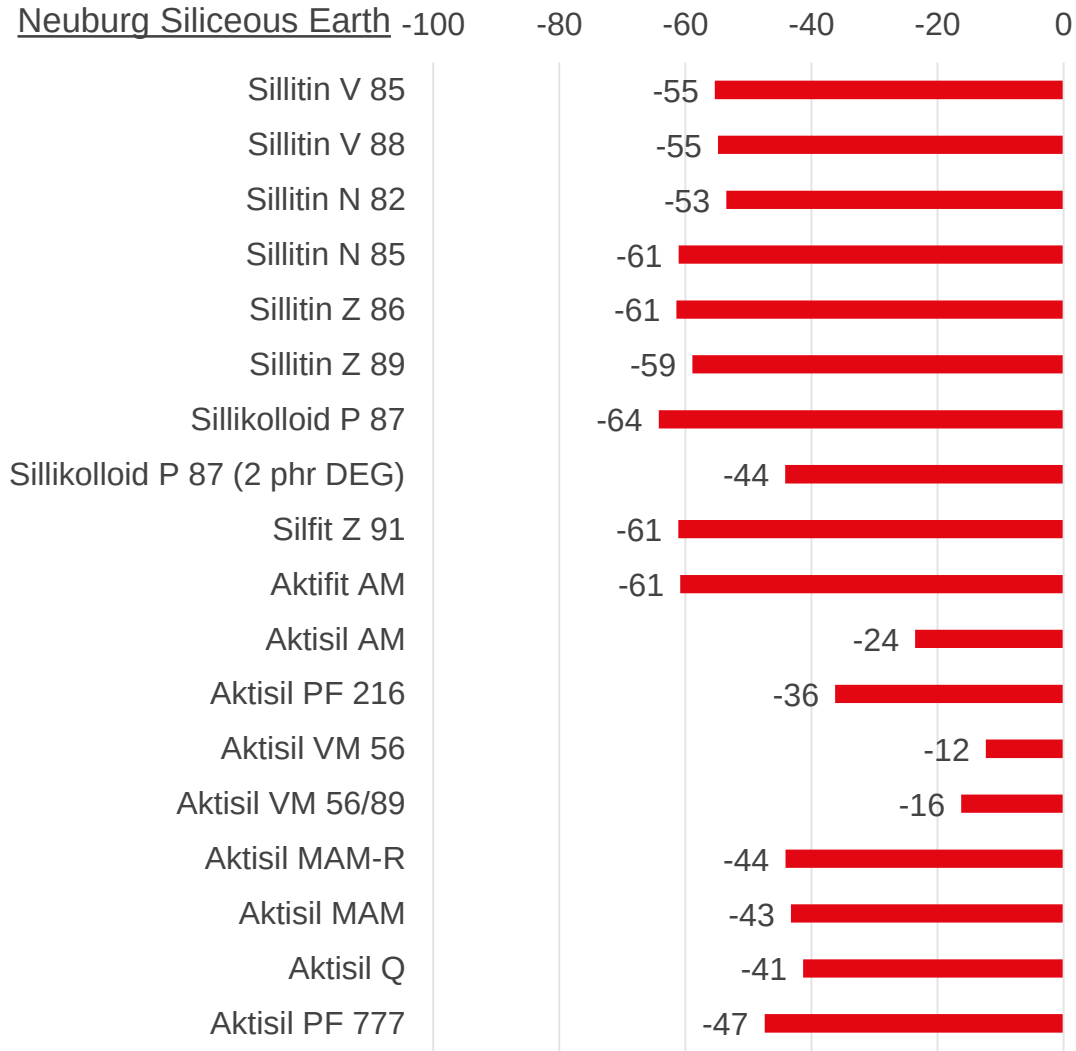


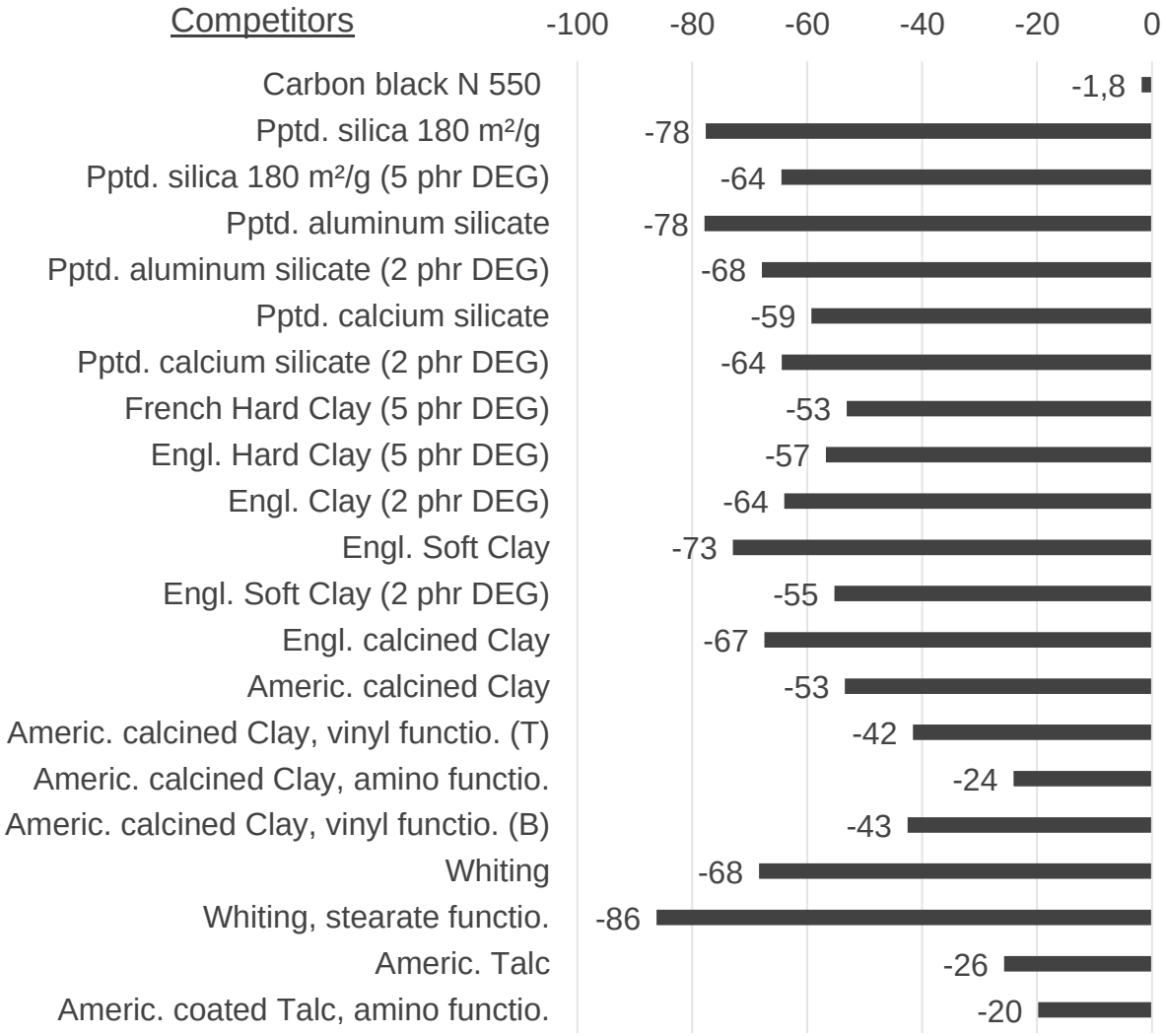
Note: Sillitin N 82 will be replaced by Sillitin N 75

Hot air aging 168 h / 125 °C
Change of tensile strength in %

Note: Sillitin N 82 will be replaced by Sillitin N 75

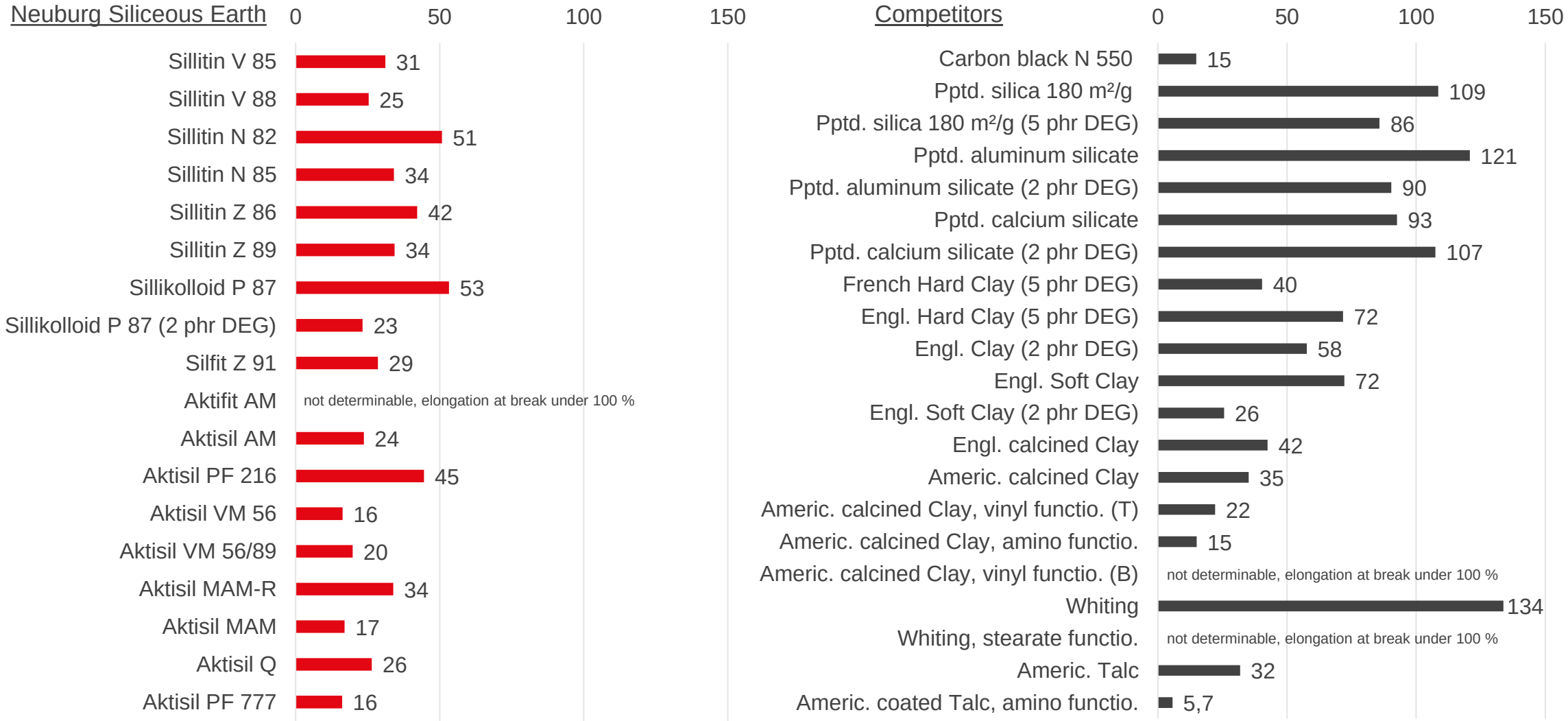
Hot air aging 168 h / 125 °C
Change of elongation at break in rel.%





Note: Sillitin N 82 will be replaced by Sillitin N 75

Hot air aging 168 h / 125 °C
Change of modulus 100 % in %



Note: Sillitin N 82 will be replaced by Sillitin N 75

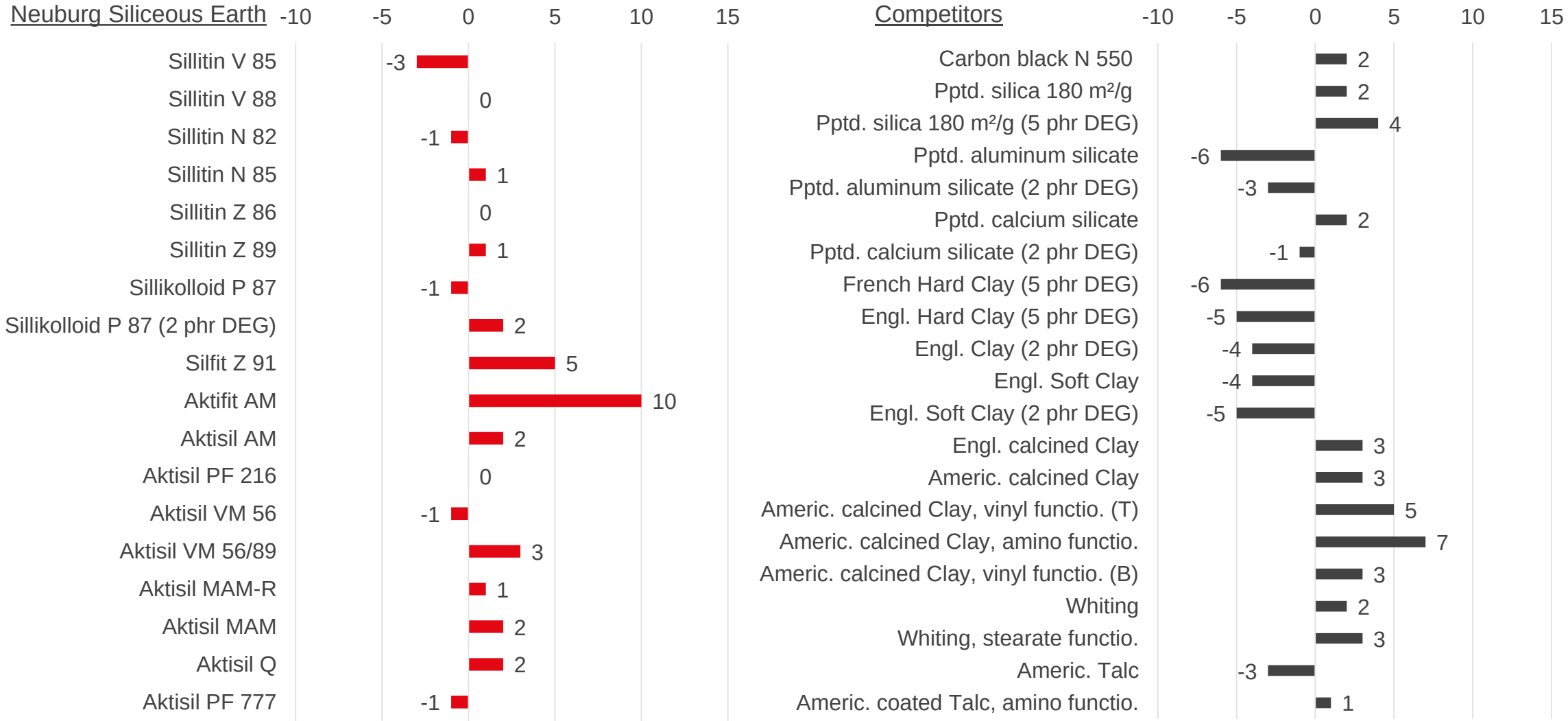
→ back to results

Immersion in deionized water 168 h / 95 °C

DIN ISO 1817

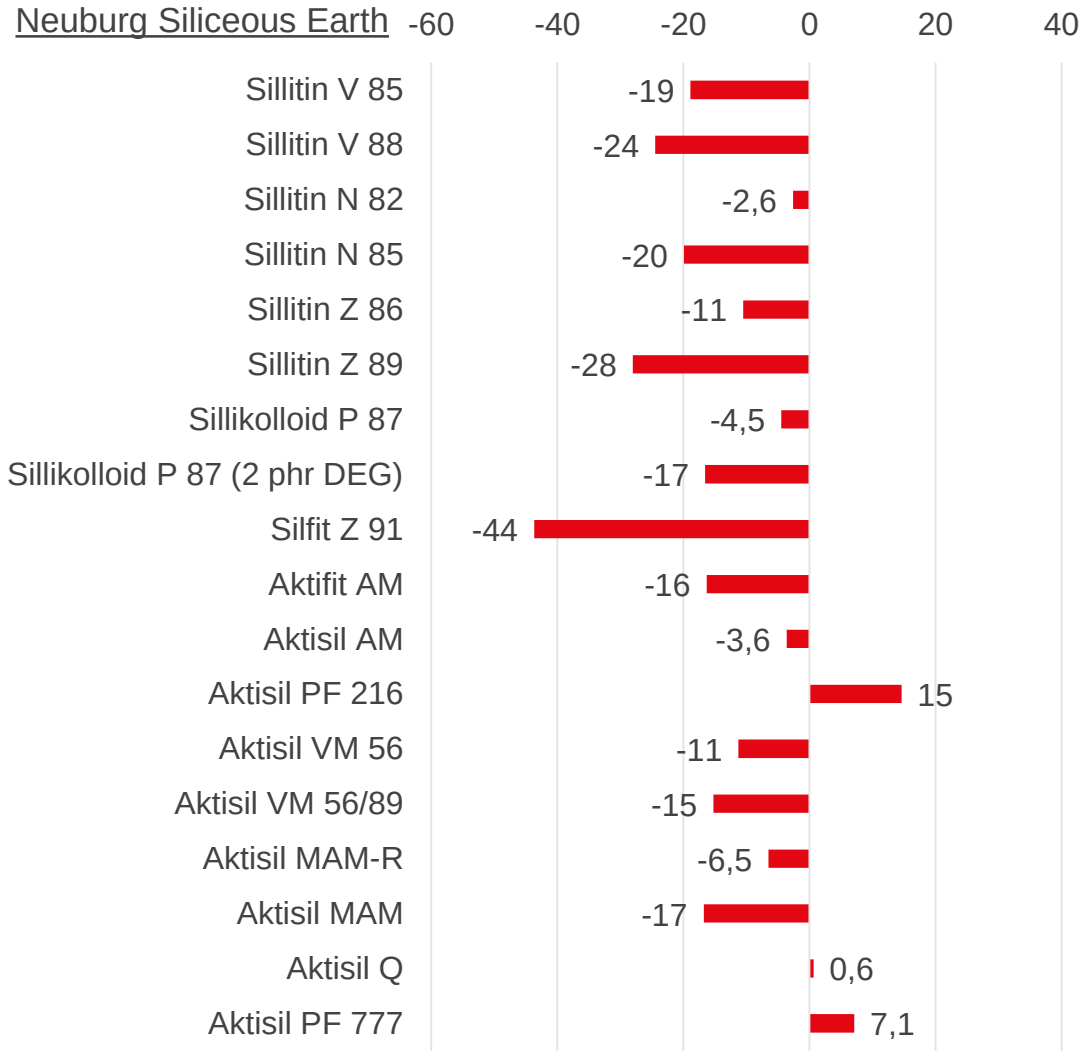
HOFFMANN MINERAL®
We supply materials for good ideas

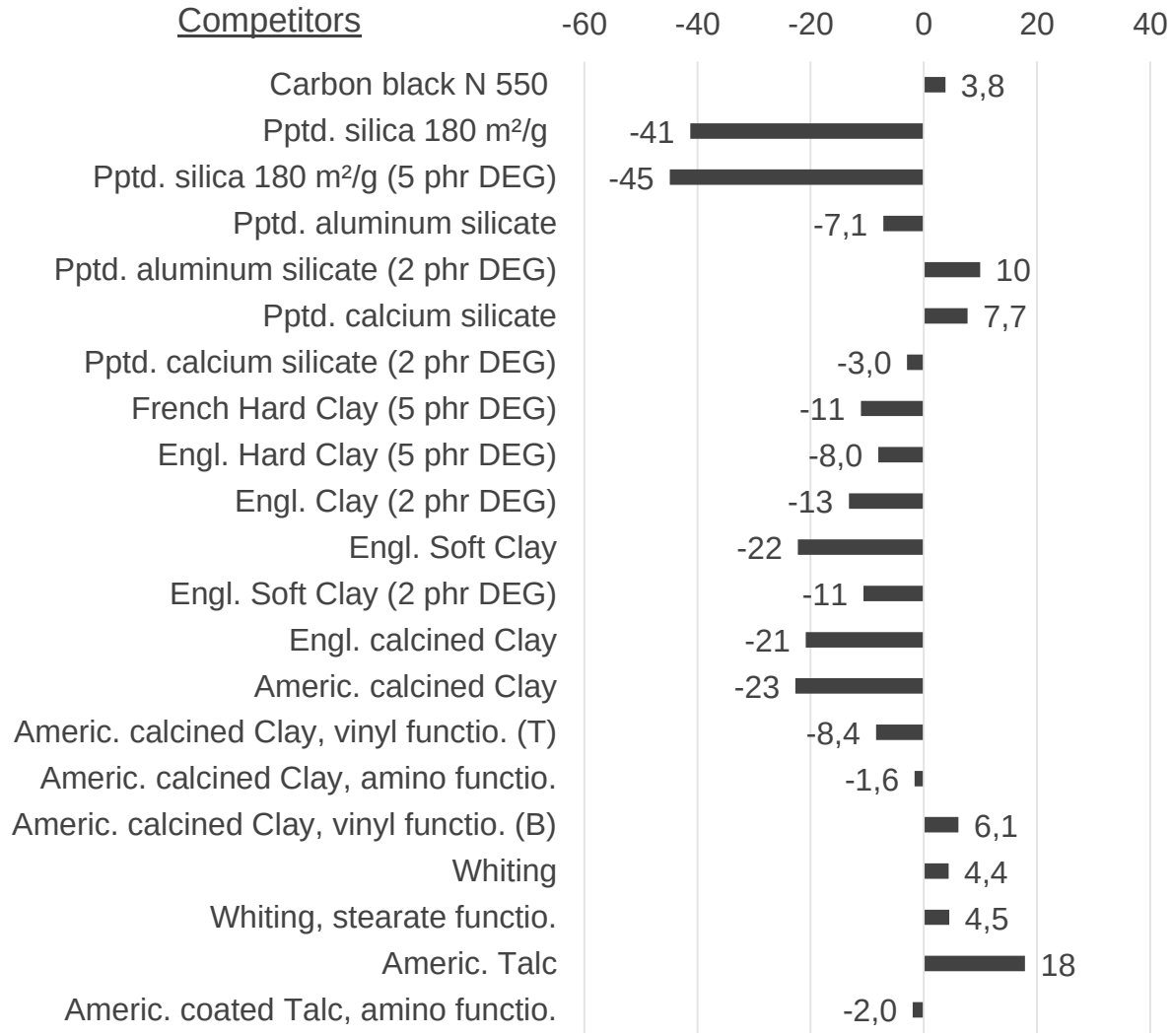
Immersion in deionized water 168 h / 95 °C
Change of hardness in Shore A – piled up S2 dumbbells



Note: Sillitin N 82 will be replaced by Sillitin N 75

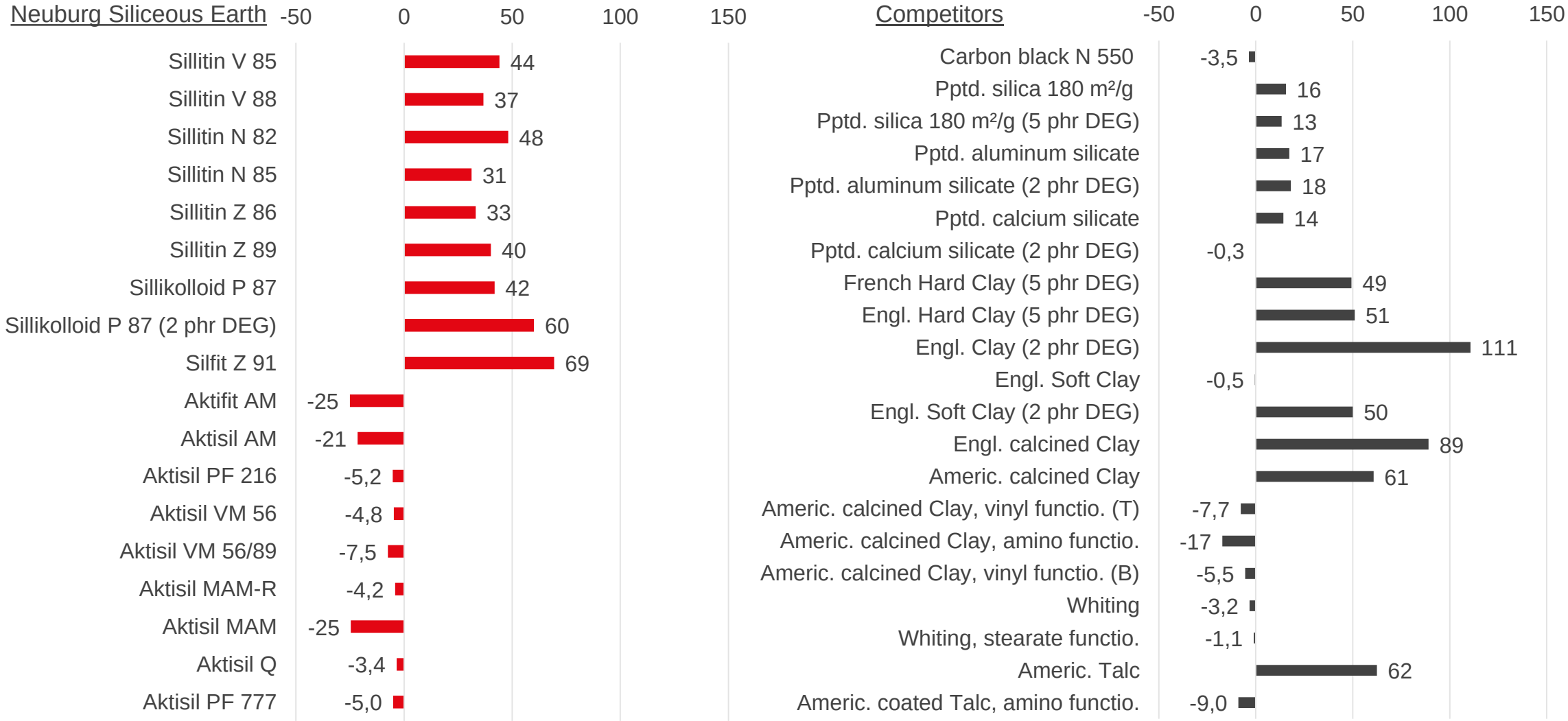
Immersion in deionized water 168 h / 95 °C
Change of tensile strength in %





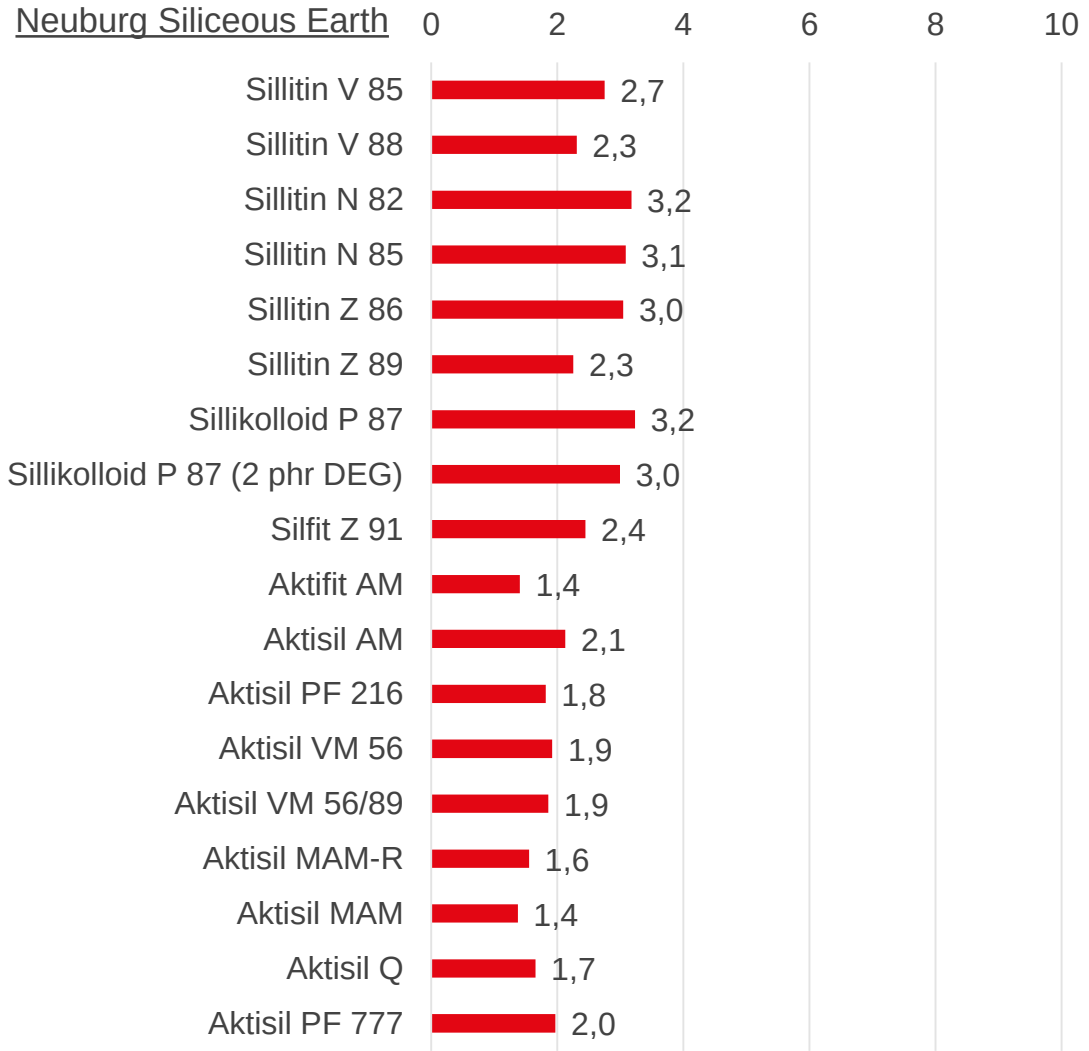
Note: Sillitin N 82 will be replaced by Sillitin N 75

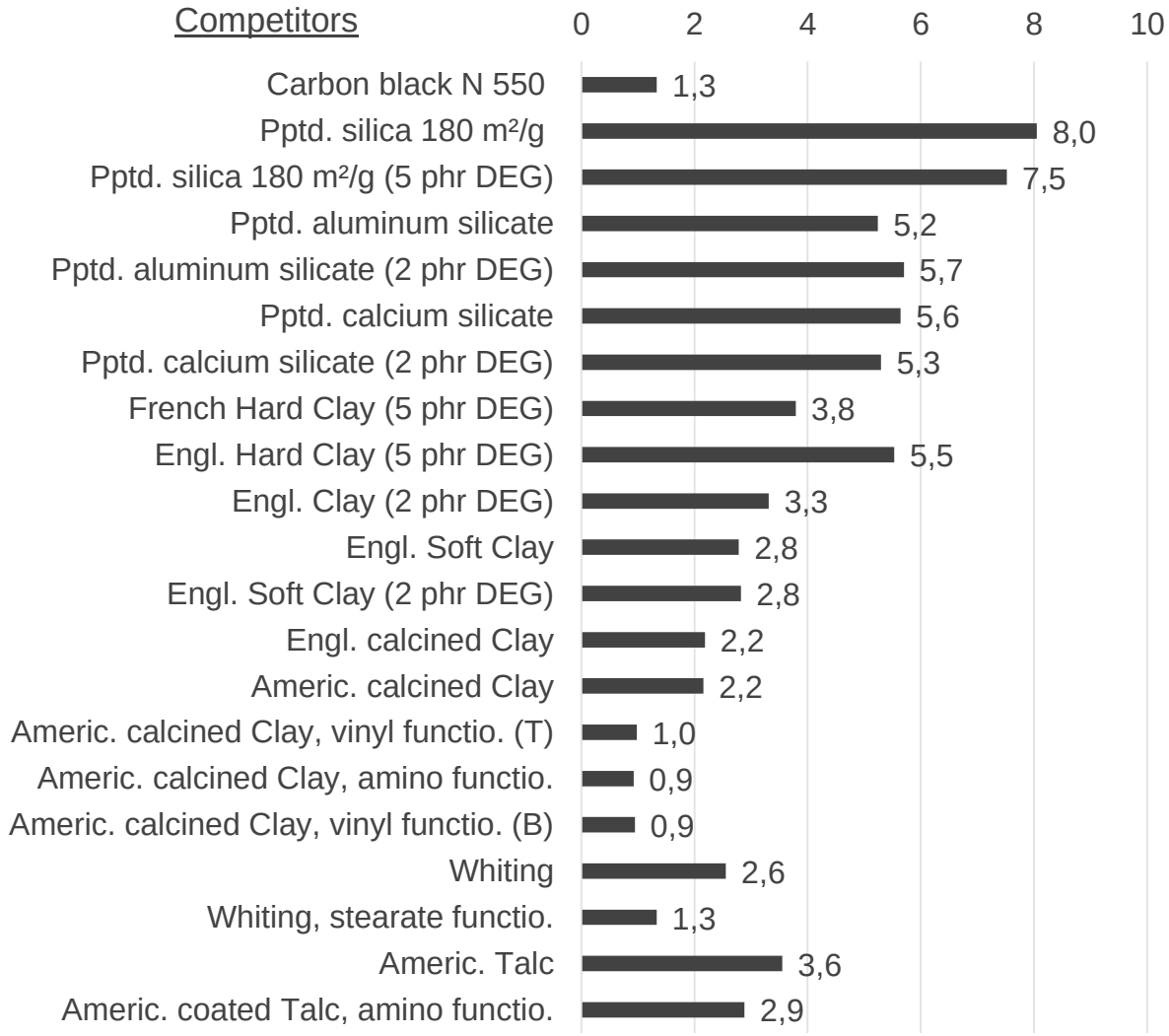
Immersion in deionized water 168 h / 95 °C
Change of elongation at break in rel.%



Note: Sillitin N 82 will be replaced by Sillitin N 75

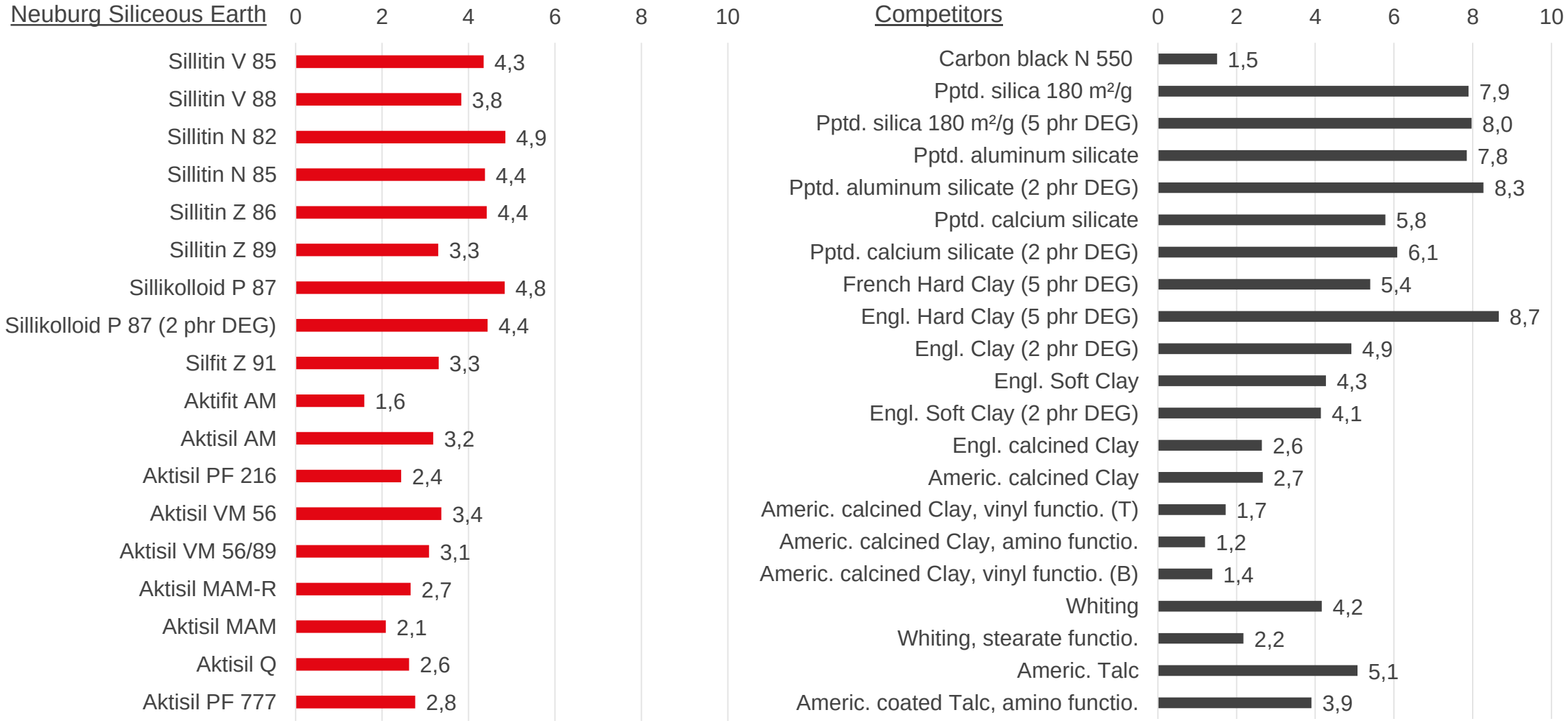
Immersion in deionized water 168 h / 95 °C
Change of weight in %





Note: Sillitin N 82 will be replaced by Sillitin N 75

Immersion in deionized water 168 h / 95 °C
Change of volume in %



Note: Sillitin N 82 will be replaced by Sillitin N 75

Summary: Special features…

... of Neuburg Siliceous Earth in peroxide-cured EPDM rubber for extrusion applications (Sillitin, Aktisil, Silfit, Aktifit)

Characteristic for the NSE:
- good processing properties with medium viscosity

Compression set:
- Silfit Z 91 and Sillitin V 88 achieve the best result of all non-functionalized fillers
- best results with methacrylic as well as amino functionalized NSE
- DEG additive in Sillikolloid P 87 reduces the compression set up to 50 % depending on the test condition

Tensile test results after vulcanization:
- good results in tensile strength and stress value 100 % with amino, tetrasulfane, vinyl- methacrylic functionalized NSE and Silfit Z 91
- Aktisil PF 777 outstanding due to very high elongation at break and good tear resistance
- non-functionalized NSE have a high elongation at break and tear resistance

Hot air aging (168 h / 100 °C; 125 °C):
- over all good resistance with Aktifit AM, Silfit Z 91, Aktisil MAM, Aktisil MAM-R and Aktisil Q
- best performance of Aktisil VM 56 and VM 56/89 at elevated temperature overall

Immersion in deionized water (168 h / 95 °C):
- good water resistance with almost all NSE products with very low weight and volume increase

We supply materials for good ideas!

HOFFMANN MINERAL GmbH
Muenchener Straße 75
DE-86633 Neuburg (Donau)

Phone: +49 8431 53-0
Internet: www.hoffmann-mineral.com
E-mail: info@hoffmann-mineral.com

→ back to results

Results in tabular form

HOFFMANN MINERAL®
We supply materials for good ideas

Properties of raw compound – Mooney Viscosity and Scorch

Neuburg Siliceous Earth	Mooney Viscosity ML 1+4 100 °C [MU]	Mooney Scorch ML +5 120 °C [min.]
Sillitin V 85	89	24
Sillitin V 88	83	24
Sillitin N 82	98	23
Sillitin N 85	89	28
Sillitin Z 86	105	13
Sillitin Z 89	91	20
Sillikolloid P 87	111	16
Sillikolloid P 87 (2 phr DEG)	109	39
Silfit Z 91	103	41
Aktifit AM	101	39
Aktisil AM	93	17
Aktisil PF 216	96	81
Aktisil VM 56	88	22
Aktisil VM 56/89	81	21
Aktisil MAM-R	75	25
Aktisil MAM	72	25
Aktisil Q	73	25
Aktisil PF 777	59	32

Competitors	Mooney Viscosity ML 1+4 100 °C [MU]	Mooney Scorch ML +5 120 °C [min.]
Carbon black N 550	85	9
Pptd. silica 180 m²/g	174	9
Pptd. silica 180 m²/g (5 phr DEG)	128	33
Pptd. aluminum silicate	120	11
Pptd. aluminum silicate (2 phr DEG)	111	18
Pptd. calcium silicate	110	19
Pptd. calcium silicate (2 phr DEG)	108	29
French Hard Clay (5 phr DEG)	99	26
Engl. Hard Clay (5 phr DEG)	95	14
Engl. Clay (2 phr DEG)	65	37
Engl. Soft Clay	49	44
Engl. Soft Clay (2 phr DEG)	54	43
Engl. calcined Clay	101	54
Americ. calcined Clay	90	55
Americ. calcined Clay, vinyl functio. (T)	78	49
Americ. calcined Clay, amino functio.	92	62
Americ. calcined Clay, vinyl functio. (B)	86	50
Whiting	51	52
Whiting, stearate functio.	42	59
Americ. Talc	52	34
Americ. coated Talc, amino functio.	56	18

Properties of raw compound – Neuburg Siliceous Earth

Rotorless Curemeter 180 °C	Torque minimum [Nm]	Cross-linking yield [Nm]	Conversion time t_5 [min.]	Conversion time t_{90} [min.]	Max. speed of vulcanization [Nm/min.]	Time until max. speed of vulcanization [min.]	tan δ
Sillitin V 85	0.21	0.61	0.3	5.2	0.49	0.4	0.17
Sillitin V 88	0.17	0.59	0.4	6.1	0.46	0.4	0.16
Sillitin N 82	0.25	0.70	0.3	4.4	0.61	0.4	0.21
Sillitin N 85	0.22	0.75	0.3	4.8	0.65	0.4	0.18
Sillitin Z 86	0.32	0.82	0.2	4.1	0.73	0.4	0.19
Sillitin Z 89	0.26	0.81	0.3	6.0	0.60	0.4	0.19
Sillikolloid P 87	0.38	0.94	0.2	4.5	0.90	0.3	0.23
Sillikolloid P 87 (2 phr DEG)	0.34	0.94	0.3	5.6	0.66	0.4	0.19
Silfit Z 91	0.37	0.76	0.4	6.0	0.67	0.3	0.15
Aktifit AM	0.23	0.72	0.4	5.5	0.47	0.4	0.14
Aktisil AM	0.17	0.54	0.4	5.7	0.41	0.4	0.15
Aktisil PF 216	0.19	0.60	0.3	6.0	0.49	0.4	0.17
Aktisil VM 56	0.17	0.55	0.4	5.9	0.47	0.4	0.16
Aktisil VM 56/89	0.18	0.59	0.4	6.0	0.49	0.4	0.17
Aktisil MAM-R	0.11	0.52	0.3	5.8	0.43	0.4	0.15
Aktisil MAM	0.11	0.53	0.3	5.6	0.46	0.4	0.15
Aktisil Q	0.11	0.59	0.3	5.3	0.58	0.3	0.15
Aktisil PF 777	0.08	0.38	0.4	6.0	0.30	0.4	0.18

Properties of raw compound – Competitors

Rotorless Curemeter 180 °C	Torque minimum [Nm]	Cross-linking yield [Nm]	Conversion time t_5 [min.]	Conversion time t_{90} [min.]	Max. speed of vulcanization [Nm/min.]	Time until max. speed of vulcanization [min.]	tan δ
Carbon black N 550	0.15	0.52	0.3	3.9	0.42	0.4	0.15
Pptd. silica 180 m²/g	0.74	1.06	0.3	3.9	1.32	0.4	0.09
Pptd. silica 180 m²/g (5 phr DEG)	0.53	1.23	0.2	3.9	1.17	0.4	0.05
Pptd. aluminum silicate	0.52	1.39	0.2	3.7	1.61	0.3	0.10
Pptd. aluminum silicate (2 phr DEG)	0.43	1.53	0.3	5.0	1.36	0.2	0.09
Pptd. calcium silicate	0.36	1.34	0.4	4.0	1.11	0.3	0.10
Pptd. calcium silicate (2 phr DEG)	0.35	1.41	0.4	4.1	1.11	0.4	0.08
French Hard Clay (5 phr DEG)	0.35	0.77	0.2	5.2	0.47	0.5	0.25
Engl. Hard Clay (5 phr DEG)	0.38	0.73	0.3	3.8	0.62	0.4	0.25
Engl. Clay (2 phr DEG)	0.17	0.55	0.3	3.8	0.46	0.5	0.23
Engl. Soft Clay	0.09	0.34	0.4	4.2	0.24	0.5	0.18
Engl. Soft Clay (2 phr DEG)	0.11	0.50	0.4	5.9	0.24	0.6	0.15
Engl. calcined Clay	0.26	0.61	0.7	5.9	0.30	0.5	0.15
Americ. calcined Clay	0.22	0.57	0.7	5.4	0.33	0.5	0.15
Americ. calcined Clay, vinyl functio. (T)	0.13	0.50	0.7	5.9	0.25	0.5	0.15
Americ. calcined Clay, amino functio.	0.16	0.51	0.4	5.8	0.28	0.5	0.11
Americ. calcined Clay, vinyl functio. (B)	0.15	0.53	0.5	7.7	0.25	0.5	0.12
Whiting	0.08	0.35	0.5	5.1	0.27	0.4	0.19
Whiting, stearate functio.	0.05	0.35	0.4	5.7	0.19	0.4	0.20
Americ. Talc	0.08	0.45	0.4	5.5	0.28	0.5	0.11
Americ. coated Talc, amino functio.	0.08	0.48	0.4	5.4	0.26	0.5	0.10

Properties of vulcanizate – Neuburg Siliceous Earth

	Hardness S2 specimen [Shore A]	Tensile strength [MPa]	Elongation at break [%]	Modulus 100 % [MPa]	Tear resistance Trousers specimen [N/mm]	Rebound elasticity [%]
Sillitin V 85	63	4.4	478	2.6	10.5	42
Sillitin V 88	62	4.5	452	2.8	9.7	44
Sillitin N 82	62	4.7	506	2.7	12.4	40
Sillitin N 85	62	4.7	470	2.7	11.1	42
Sillitin Z 86	64	5.1	548	2.7	13.7	39
Sillitin Z 89	63	6.1	470	2.9	12.3	40
Sillikolloid P 87	64	5.3	548	2.6	14.2	37
Sillikolloid P 87 (2 phr DEG)	66	5.7	433	3.4	11.1	35
Silfit Z 91	64	6.4	333	3.6	7.8	40
Aktifit AM	68	8.5	213	5.2	4.0	40
Aktisil AM	65	7.5	251	4.5	5.3	40
Aktisil PF 216	67	7.9	257	4.5	4.8	41
Aktisil VM 56	66	8.6	279	3.9	5.4	41
Aktisil VM 56/89	65	8.9	269	4.1	5.4	40
Aktisil MAM-R	64	6.8	246	3.8	4.2	43
Aktisil MAM	63	6.4	235	4.0	3.6	44
Aktisil Q	65	7.3	219	4.3	3.5	43
Aktisil PF 777	59	4.3	758	2.2	13.2	40

Properties of vulcanizate – Competitors

	Hardness S2 specimen [Shore A]	Tensile strength [MPa]	Elongation at break [%]	Modulus 100 % [MPa]	Tear resistance Trousers specimen [N/mm]	Rebound elasticity [%]
Carbon black N 550	68	12.6	182	5.8	3.2	34
Pptd. silica 180 m²/g	72	14.8	595	2.1	19.2	48
Pptd. silica 180 m²/g (5 phr DEG)	67	17.7	604	1.8	13.8	45
Pptd. aluminum silicate	66	8.5	545	2.3	11.7	46
Pptd. aluminum silicate (2 phr DEG)	66	7.3	521	2.2	12.2	46
Pptd. calcium silicate	66	5.1	489	2.4	9.3	n.d.
Pptd. calcium silicate (2 phr DEG)	68	5.4	546	2.3	9.8	n.d.
French Hard Clay (5 phr DEG)	66	5.4	461	3.3	10.2	32
Engl. Hard Clay (5 phr DEG)	66	5.2	455	2.9	10.8	33
Engl. Clay (2 phr DEG)	64	4.7	319	3.4	10.1	40
Engl. Soft Clay	57	3.0	549	2.2	11.9	48
Engl. Soft Clay (2 phr DEG)	64	3.5	431	3.1	10.7	43
Engl. calcined Clay	67	5.2	312	3.8	7.5	38
Americ. calcined Clay	63	5.8	404	3.3	9.8	41
Americ. calcined Clay, vinyl functio. (T)	65	7.6	228	4.9	4.8	40
Americ. calcined Clay, amino functio.	65	8.0	199	5.1	3.3	45
Americ. calcined Clay, vinyl functio. (B)	68	8.0	172	5.9	3.2	41
Whiting	48	3.8	781	1.2	7.2	46
Whiting, stearate functio.	48	3.0	686	1.0	5.5	45
Americ. Talc	63	4.3	328	3.4	8.4	44
Americ. coated Talc, amino functio.	66	5.7	148	4.9	3.7	46

n.d.: not determinable, specimen inflated

Properties of vulcanizate – Compression set

Neuburg Siliceous Earth	**CS 100 °C** 24 h / 25 % Def.	**CS 125 °C** 24 h / 25 % Def.	**CS 150 °C** 24 h / 25 % Def.
Sillitin V 85	18.4	23.0	33.5
Sillitin V 88	15.3	17.1	28.3
Sillitin N 82	26.9	31.0	43.3
Sillitin N 85	22.1	25.2	38.2
Sillitin Z 86	28.1	37.4	45.5
Sillitin Z 89	18.6	25.5	34.2
Sillikolloid P 87	40.6	48.6	60.3
Sillikolloid P 87 (2 phr DEG)	21.4	29.9	39.5
Silfit Z 91	12.8	20.4	29.2
Aktifit AM	10.2	14.7	21.2
Aktisil AM	13.1	15.8	23.1
Aktisil PF 216	25.0	34.2	55.6
Aktisil VM 56	19.1	17.1	29.7
Aktisil VM 56/89	20.8	24.3	33.3
Aktisil MAM-R	9.6	12.7	22.9
Aktisil MAM	9.0	14.2	21.2
Aktisil Q	9.0	15.1	21.3
Aktisil PF 777	17.1	19.9	29.4

Competitors	**CS 100 °C** 24 h / 25 % Def.	**CS 125 °C** 24 h / 25 % Def.	**CS 150 °C** 24 h / 25 % Def.
Carbon black N 550	9.6	14.5	29.4
Pptd. silica 180 m²/g	53.7	57.4	72.2
Pptd. silica 180 m²/g (5 phr DEG)	46.0	60.8	71.2
Pptd. aluminum silicate	49.7	62.4	75.2
Pptd. aluminum silicate (2 phr DEG)	52.6	65.4	78.7
Pptd. calcium silicate	33.7	45.7	59.1
Pptd. calcium silicate (2 phr DEG)	37.8	49.7	63.1
French Hard Clay (5 phr DEG)	34.9	43.4	55.2
Engl. Hard Clay (5 phr DEG)	33.5	39.2	52.5
Engl. Clay (2 phr DEG)	32.9	38.4	46.4
Engl. Soft Clay	32.1	37.6	46.8
Engl. Soft Clay (2 phr DEG)	15.6	18.1	32.9
Engl. calcined Clay	19.2	23.8	31.5
Americ. calcined Clay	18.3	22.1	29.1
Americ. calcined Clay, vinyl functio. (T)	15.7	19.2	26.4
Americ. calcined Clay, amino functio.	10.6	13.8	20.0
Americ. calcined Clay, vinyl functio. (B)	13.8	16.5	23.5
Whiting	15.7	23.2	26.6
Whiting, stearate functio.	16.1	19.0	23.9
Americ. Talc	21.5	25.5	34.9
Americ. coated Talc, amino functio.	19.5	23.2	33.6

Hot air aging 168 h / 100 °C – Neuburg Siliceous Earth

	Change of hardness S2 specimen [Shore A]	Change of tensile strength [%]	Change of elongation at break [rel.%]	Change of modulus 100 % [%]
Sillitin V 85	3	4.6	-38.8	12.4
Sillitin V 88	3	1.7	-43.3	8.0
Sillitin N 82	5	5.4	-33.7	16.4
Sillitin N 85	7	1.2	-50.0	16.6
Sillitin Z 86	4	0.2	-47.1	20.0
Sillitin Z 89	3	-11.3	-43.1	13.4
Sillikolloid P 87	10	2.5	-50.1	33.4
Sillikolloid P 87 (2 phr DEG)	4	0.5	-30.6	11.3
Silfit Z 91	7	-12.9	-37.1	3.0
Aktifit AM	3	-2.2	-12.1	8.0
Aktisil AM	4	5.5	-19.5	21.4
Aktisil PF 216	5	3.1	-20.9	15.1
Aktisil VM 56	3	-13.4	-15.3	6.9
Aktisil VM 56/89	6	-17.1	-18.7	9.5
Aktisil MAM-R	2	-6.0	-11.8	3.9
Aktisil MAM	2	-4.7	-13.2	-7.3
Aktisil Q	3	-3.3	-5.0	-1.7
Aktisil PF 777	4	-10.6	-8.2	13.1

Hot air aging 168 h / 100 °C – Competitors

	Change of hardness S2 specimen [Shore A]	Change of tensile strength [%]	Change of elongation at break [rel.%]	Change of modulus 100 % [%]
Carbon black N 550	2	4.5	2.7	3.8
Pptd. silica 180 m²/g	4	-26.4	-40.7	41.8
Pptd. silica 180 m²/g (5 phr DEG)	6	-17.7	-32.6	44.5
Pptd. aluminum silicate	10	35.0	-55.7	76.6
Pptd. aluminum silicate (2 phr DEG)	9	58.1	-52.2	84.9
Pptd. calcium silicate	11	58.8	-60.0	84.3
Pptd. calcium silicate (2 phr DEG)	7	51.0	-64.1	101.1
French Hard Clay (5 phr DEG)	8	3.1	-38.5	22.3
Engl. Hard Clay (5 phr DEG)	5	15.6	-49.1	46.9
Engl. Clay (2 phr DEG)	4	12.3	-29.9	25.3
Engl. Soft Clay	4	29.9	-53.6	41.6
Engl. Soft Clay (2 phr DEG)	1	9.3	-45.8	13.7
Engl. calcined Clay	3	5.1	-52.7	28.6
Americ. calcined Clay	3	3.3	-59.7	47.2
Americ. calcined Clay, vinyl functio. (T)	3	-16.5	-38.1	17.5
Americ. calcined Clay, amino functio.	4	-7.4	-13.0	4.8
Americ. calcined Clay, vinyl functio. (B)	2	4.0	-1.5	4.9
Whiting	2	-32.6	-8.8	8.8
Whiting, stearate functio.	13	-12.6	-43.0	121.3
Americ. Talc	3	11.3	-0.1	24.8
Americ. coated Talc, amino functio.	2	5.7	-12.6	9.6

Hot air aging 168 h / 125 °C – Neuburg Siliceous Earth

	Change of hardness S2 specimen [Shore A]	Change of tensile strength [%]	Change of elongation at break [rel.%]	Change of modulus 100 % [%]
Sillitin V 85	8	15.8	-55.3	31.1
Sillitin V 88	5	8.6	-54.8	25.3
Sillitin N 82	8	19.6	-53.5	50.8
Sillitin N 85	6	3.7	-61.1	34.1
Sillitin Z 86	10	7.1	-61.4	42.2
Sillitin Z 89	6	-6.5	-58.9	34.3
Sillikolloid P 87	9	5.9	-64.2	53.3
Sillikolloid P 87 (2 phr DEG)	5	12.3	-44.1	23.2
Silfit Z 91	6	-12.4	-61.1	28.6
Aktifit AM	12	-18.6	-60.8	n.d.
Aktisil AM	5	17.9	-23.5	23.6
Aktisil PF 216	7	9.6	-36.2	44.5
Aktisil VM 56	4	-7.9	-12.3	16.3
Aktisil VM 56/89	6	-11.2	-16.2	19.8
Aktisil MAM-R	7	-14.6	-44.1	33.9
Aktisil MAM	6	-16.7	-43.3	17.0
Aktisil Q	7	-15.7	-41.3	26.4
Aktisil PF 777	6	-22.4	-47.4	16.1

n.d.: not determinable, elongation at break under 100 %

Hot air aging 168 h / 125 °C – Competitors

	Change of hardness S2 specimen [Shore A]	Change of tensile strength [%]	Change of elongation at break [rel.%]	Change of modulus 100 % [%]
Carbon black N 550	5	-8.4	-1.8	14.8
Pptd. silica 180 m²/g	6	-63.6	-77.7	108.6
Pptd. silica 180 m²/g (5 phr DEG)	7	-61.9	-64.5	85.8
Pptd. aluminum silicate	10	-25.7	-77.9	120.8
Pptd. aluminum silicate (2 phr DEG)	12	26.7	-67.9	90.4
Pptd. calcium silicate	10	81.7	-59.2	92.6
Pptd. calcium silicate (2 phr DEG)	8	70.3	-64.4	107.5
French Hard Clay (5 phr DEG)	8	10.9	-53.1	40.4
Engl. Hard Clay (5 phr DEG)	9	25.2	-56.7	71.7
Engl. Clay (2 phr DEG)	8	16.2	-64.0	57.7
Engl. Soft Clay	11	32.3	-72.9	72.2
Engl. Soft Clay (2 phr DEG)	2	14.2	-55.3	25.6
Engl. calcined Clay	7	10.1	-67.4	42.5
Americ. calcined Clay	5	5.8	-53.4	35.2
Americ. calcined Clay, vinyl functio. (T)	5	-11.5	-41.6	22.2
Americ. calcined Clay, amino functio.	5	-4.2	-24.1	15.1
Americ. calcined Clay, vinyl functio. (B)	4	-17.7	-42.5	n.d.
Whiting	13	-25.4	-68.4	133.8
Whiting, stearate functio.	18	5.6	-86.2	n.d.
Americ. Talc	5	13.2	-25.7	31.8
Americ. coated Talc, amino functio.	3	-1.1	-19.8	5.7

n.d.: not determinable, elongation at break under 100 %

Immersion in deionized water 168 h / 95 °C – Neuburg Siliceous Earth

	Change of hardness S2 specimen [Shore A]	Change of tensile strength [%]	Change of elongation at break [rel.%]	Change of weight [%]	Change of volume [%]
Sillitin V 85	-3	-18.9	44.1	2.7	4.3
Sillitin V 88	0	-24.5	36.8	2.3	3.8
Sillitin N 82	-1	-2.6	48.2	3.2	4.9
Sillitin N 85	1	-19.9	31.2	3.1	4.4
Sillitin Z 86	0	-10.5	33.2	3.0	4.4
Sillitin Z 89	1	-28.0	40.1	2.3	3.3
Sillikolloid P 87	-1	-4.5	41.9	3.2	4.8
Sillikolloid P 87 (2 phr DEG)	2	-16.5	60.1	3.0	4.4
Silfit Z 91	5	-43.7	69.4	2.4	3.3
Aktifit AM	10	-16.3	-25.1	1.4	1.6
Aktisil AM	2	-3.6	-21.5	2.1	3.2
Aktisil PF 216	0	14.6	-5.2	1.8	2.4
Aktisil VM 56	-1	-11.2	-4.8	1.9	3.4
Aktisil VM 56/89	3	-15.2	-7.5	1.9	3.1
Aktisil MAM-R	1	-6.5	-4.2	1.6	2.7
Aktisil MAM	2	-16.8	-24.6	1.4	2.1
Aktisil Q	2	0.6	-3.4	1.7	2.6
Aktisil PF 777	-1	7.1	-5.0	2.0	2.8

Immersion in deionized water 168 h / 95 °C – Competitors

	Change of hardness S2 specimen [Shore A]	Change of tensile strength [%]	Change of elongation at break [rel.%]	Change of weight [%]	Change of volume [%]
Carbon black N 550	2	3.8	-3.5	1.3	1.5
Pptd. silica 180 m²/g	2	-41.2	15.6	8.0	7.9
Pptd. silica 180 m²/g (5 phr DEG)	4	-44.9	13.3	7.5	8.0
Pptd. aluminum silicate	-6	-7.1	17.3	5.2	7.8
Pptd. aluminum silicate (2 phr DEG)	-3	9.9	18.1	5.7	8.3
Pptd. calcium silicate	2	7.7	14.2	5.6	5.8
Pptd. calcium silicate (2 phr DEG)	-1	-3.0	-0.3	5.3	6.1
French Hard Clay (5 phr DEG)	-6	-11.1	49.4	3.8	5.4
Engl. Hard Clay (5 phr DEG)	-5	-8.0	51.0	5.5	8.7
Engl. Clay (2 phr DEG)	-4	-13.2	110.6	3.3	4.9
Engl. Soft Clay	-4	-22.2	-0.5	2.8	4.3
Engl. Soft Clay (2 phr DEG)	-5	-10.7	50.0	2.8	4.1
Engl. calcined Clay	3	-20.8	89.1	2.2	2.6
Americ. calcined Clay	3	-22.7	60.7	2.2	2.7
Americ. calcined Clay, vinyl functio. (T)	5	-8.4	-7.7	1.0	1.7
Americ. calcined Clay, amino functio.	7	-1.6	-17.3	0.9	1.2
Americ. calcined Clay, vinyl functio. (B)	3	6.1	-5.5	0.9	1.4
Whiting	2	4.4	-3.2	2.6	4.2
Whiting, stearate functio.	3	4.5	-1.1	1.3	2.2
Americ. Talc	-3	17.9	62.5	3.6	5.1
Americ. coated Talc, amino functio.	1	-2.0	-9.0	2.9	3.9

Garvey extrusion – Neuburg Siliceous Earth

	Assessment Garvey profile at 2.0 m/min. haul-off speed				Extruder torque at 2.0 m/min. [Nm]	Max. extrusion speed with Garvey profile 4444 haul-off speed [m/min.]	Max. extrusion speed with Garvey profile 4444 Extruder torque [Nm]
	swelling	30° edge	surface	corners			
Sillitin V 85	4.0	2	4	4.0	140	Already at 2 m/min. no 4444 assessment reached	Already at 2 m/min. no 4444 assessment reached
Sillitin V 88	4.0	2	4	4.0	135	Already at 2 m/min. no 4444 assessment reached	Already at 2 m/min. no 4444 assessment reached
Sillitin N 82	4.0	2	4	4.0	135	Already at 2 m/min. no 4444 assessment reached	Already at 2 m/min. no 4444 assessment reached
Sillitin N 85	4.0	2	4	4.0	135	Already at 2 m/min. no 4444 assessment reached	Already at 2 m/min. no 4444 assessment reached
Sillitin Z 86	4.0	4	4	4.0	140	2.0	140
Sillitin Z 89	4.0	4	4	4.0	140	4.5	160
Sillikolloid P 87	4.0	3.5	4	4.0	145	Already at 2 m/min. no 4444 assessment reached	Already at 2 m/min. no 4444 assessment reached
Sillikolloid P 87 (2 phr DEG)	4.0	4	4	4.0	145	4.0	165
Silfit Z 91	4.0	4	4	4.0	145	5.5	170
Aktifit AM	4.0	4	4	4.0	145	10.0	190
Aktisil AM	4.0	4	4	4.0	130	3.0	150
Aktisil PF 216	4.0	4	4	4.0	130	6.0	165
Aktisil VM 56	4.0	4	4	4.0	140	4.5	145
Aktisil VM 56/89	4.0	4	4	4.0	140	7.0	160
Aktisil MAM-R	4.0	4	4	4.0	125	3.5	140
Aktisil MAM	4.0	4	4	4.0	125	3.0	130
Aktisil Q	4.0	4	4	4.0	120	4.5	150
Aktisil PF 777	4.0	4	4	4.0	130	4.5	155

Garvey extrusion – Competitors

	Assessment Garvey profile at 2.0 m/min. haul-off speed				Extruder torque at 2.0 m/min. [Nm]	Max. extrusion speed with Garvey profile 4444 haul-off speed [m/min.]	Max. extrusion speed with Garvey profile 4444 Extruder torque [Nm]
	swelling	30° edge	surface	corners			
Carbon black N 550	4.0	4	4	4.0	150	13.0 (higher speed possible)	200
Pptd. silica 180 m²/g	4.0	1.5	4	3.3	180	Already at 2 m/min. no 4444 assessment reached	Already at 2 m/min. no 4444 assessment reached
Pptd. silica 180 m²/g (5 phr DEG)	4.0	1.5	4	3.2	165	Already at 2 m/min. no 4444 assessment reached	Already at 2 m/min. no 4444 assessment reached
Pptd. aluminum silicate	4.0	1	3.5	2.2	160	Already at 2 m/min. no 4444 assessment reached	Already at 2 m/min. no 4444 assessment reached
Pptd. aluminum silicate (2 phr DEG)	4.0	1	3.5	2.2	150	Already at 2 m/min. no 4444 assessment reached	Already at 2 m/min. no 4444 assessment reached
Pptd. calcium silicate	4.0	1.5	4	3.5	145	Already at 2 m/min. no 4444 assessment reached	Already at 2 m/min. no 4444 assessment reached
Pptd. calcium silicate (2 phr DEG)	4.0	1.5	4	2.2	145	Already at 2 m/min. no 4444 assessment reached	Already at 2 m/min. no 4444 assessment reached
French Hard Clay (5 phr DEG)	4.0	1	3	1.3	115	Already at 2 m/min. no 4444 assessment reached	Already at 2 m/min. no 4444 assessment reached
Engl. Hard Clay (5 phr DEG)	4.0	1.5	4	2.0	130	Already at 2 m/min. no 4444 assessment reached	Already at 2 m/min. no 4444 assessment reached
Engl. Clay (2 phr DEG)	4.0	1	4	2.8	120	Already at 2 m/min. no 4444 assessment reached	Already at 2 m/min. no 4444 assessment reached
Engl. Soft Clay	4.0	1.5	4	2.8	110	Already at 2 m/min. no 4444 assessment reached	Already at 2 m/min. no 4444 assessment reached
Engl. Soft Clay (2 phr DEG)	4.0	1.5	4	2.0	110	Already at 2 m/min. no 4444 assessment reached	Already at 2 m/min. no 4444 assessment reached
Engl. calcined Clay	4.0	4	4	4.0	140	3.0	140
Americ. calcined Clay	4.0	4	4	4.0	130	4.0	145
Americ. calcined Clay, vinyl functio. (T)	4.0	4	4	4.0	125	4.5	150
Americ. calcined Clay, amino functio.	4.0	4	4	4.0	120	5.5	150
Americ. calcined Clay, vinyl functio. (B)	4.0	4	4	4.0	120	2.5	130
Whiting	4.0	2.5	4	3.3	110	Already at 2 m/min. no 4444 assessment reached	Already at 2 m/min. no 4444 assessment reached
Whiting, stearate functio.	4.0	2.5	4	3.3	105	Already at 2 m/min. no 4444 assessment reached	Already at 2 m/min. no 4444 assessment reached
Americ. Talc	4.0	2.5	3.5	2.7	100	Already at 2 m/min. no 4444 assessment reached	Already at 2 m/min. no 4444 assessment reached
Americ. coated Talc, amino functio.	4.0	1.5	3	2.2	110	Already at 2 m/min. no 4444 assessment reached	Already at 2 m/min. no 4444 assessment reached

→ back to results

Images Garvey extrudates

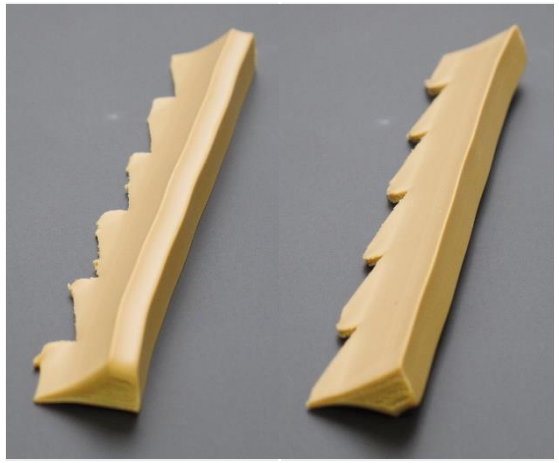
back to diagram

HOFFMANN MINERAL®
We supply materials for good ideas

Garvey extrusion - extrudates at 2.0 m/min haul-off speed

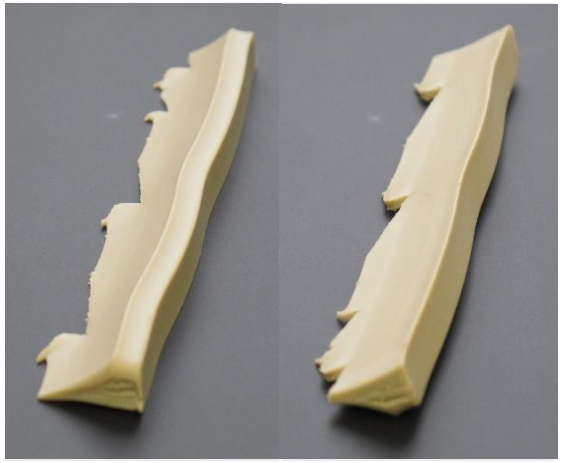
Sillitin V 85

front | back



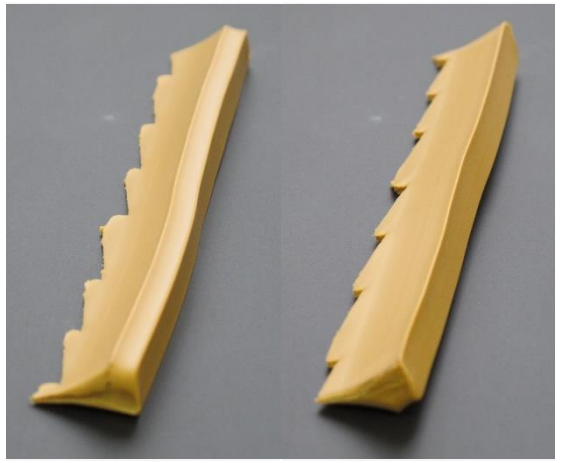
Sillitin V 88

front | back



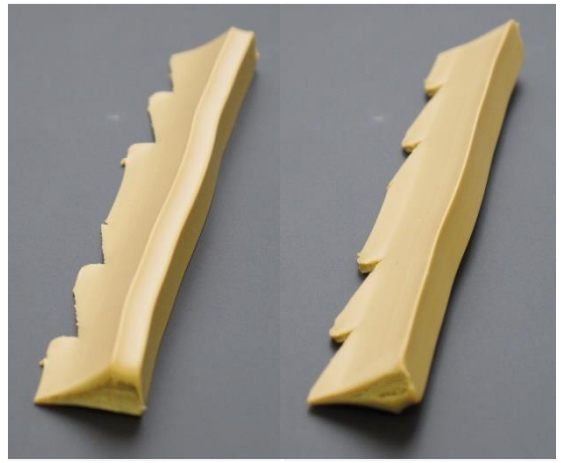
Sillitin N 82

front | back



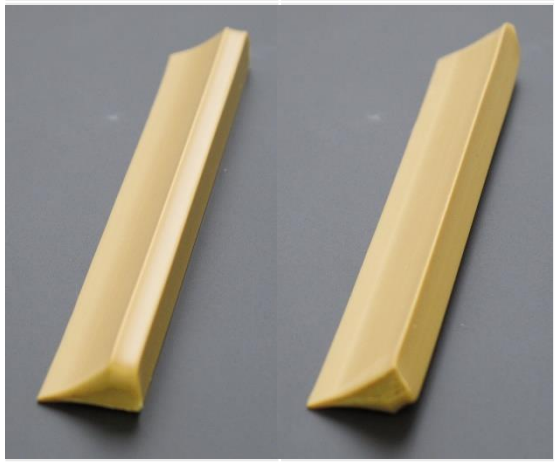
Sillitin N 85

front | back



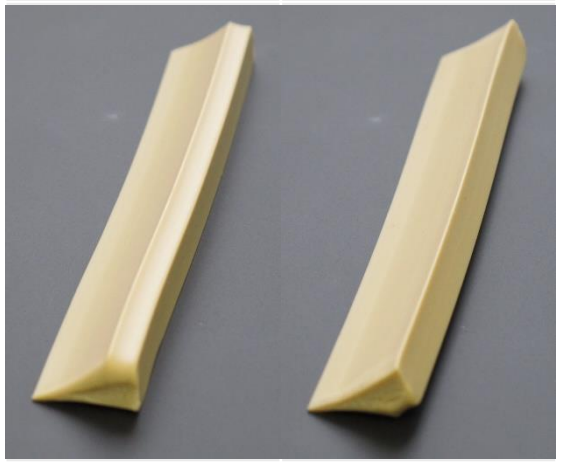
Sillitin Z 86

front | back



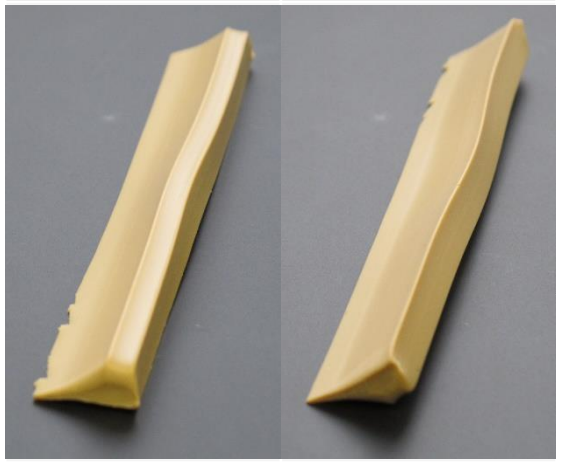
Sillitin Z 89

front | back



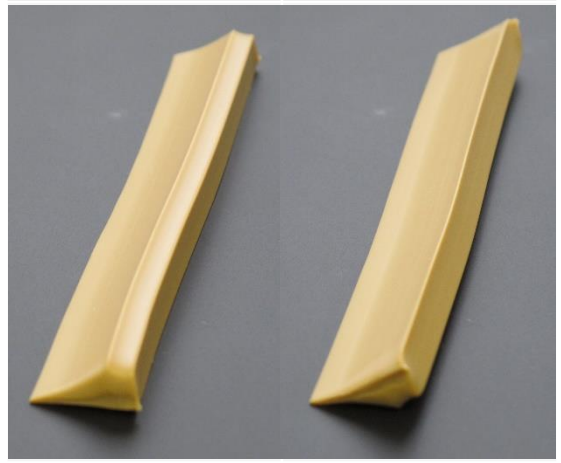
Sillikolloid P 87

front | back



Sillikolloid P 87 with DEG

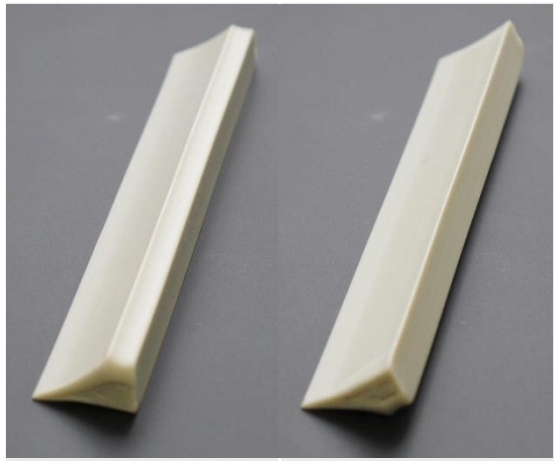
front | back



Garvey extrusion - extrudates at 2.0 m/min haul-off speed

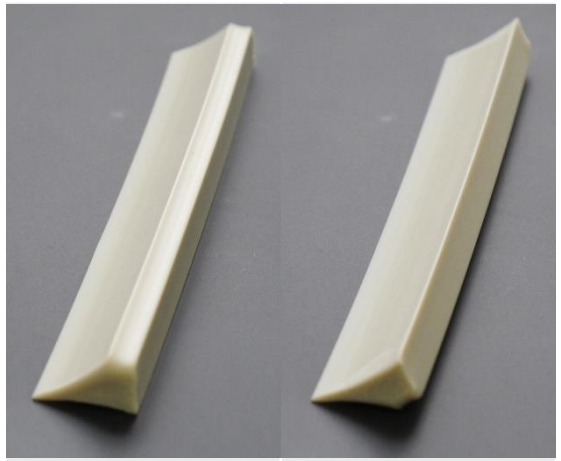
Silfit Z 91

front | back



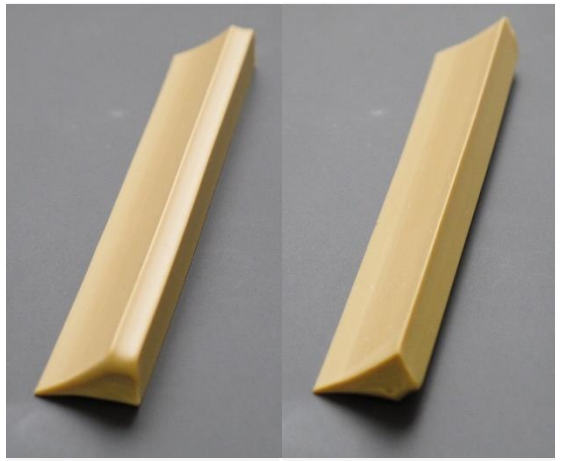
Aktifit AM

front | back



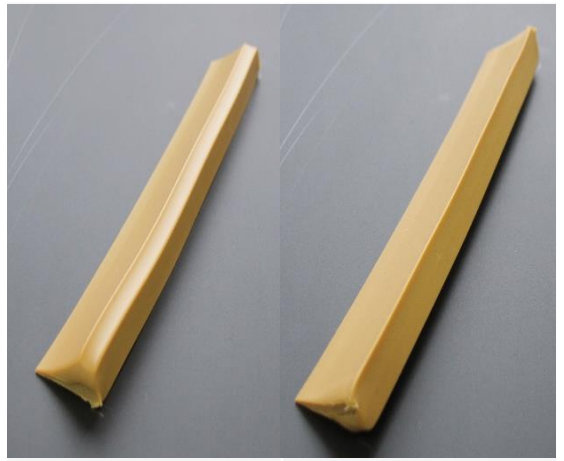
Aktisil AM

front | back



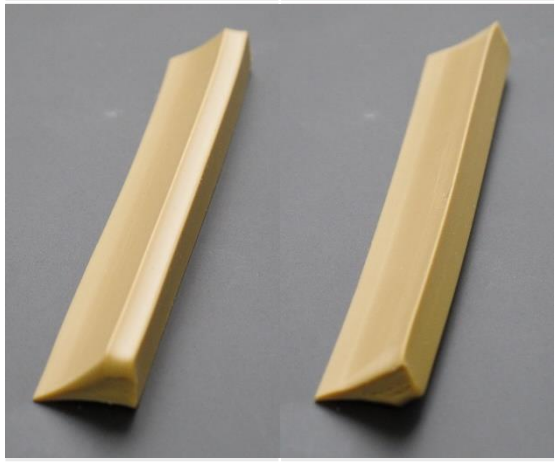
Aktisil PF 216

front | back



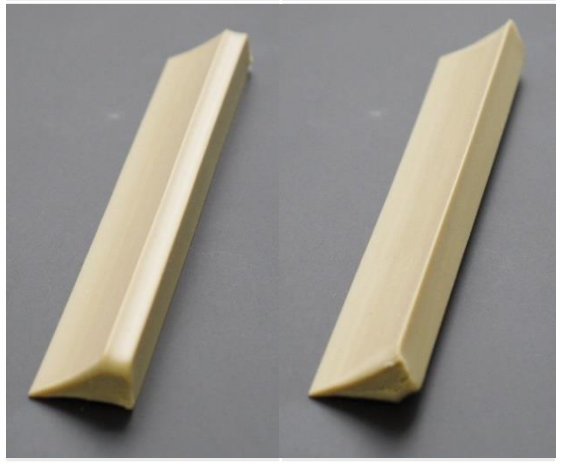
Aktisil VM 56

front | back



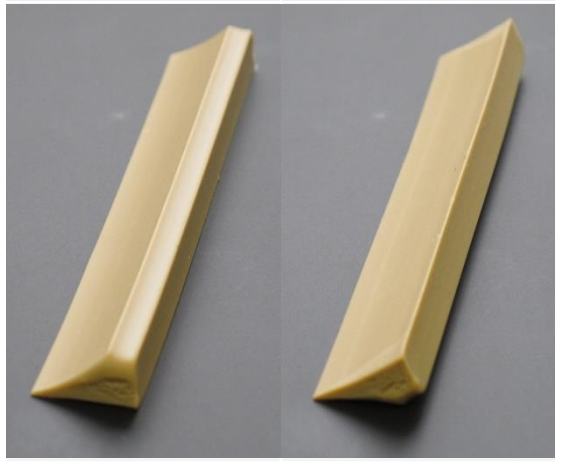
Aktisil VM 56/89

front | back



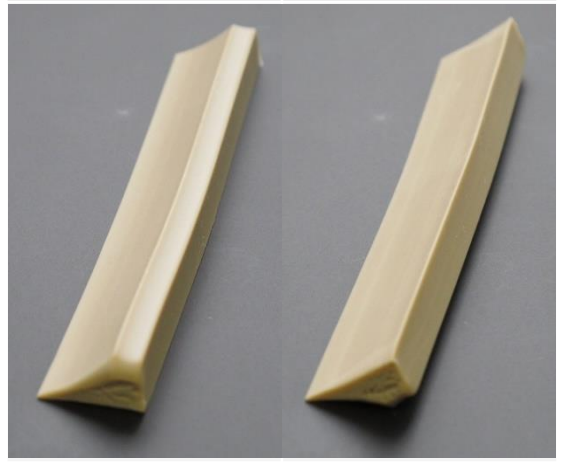
Aktisil MAM-R

front | back



Aktisil MAM

front | back

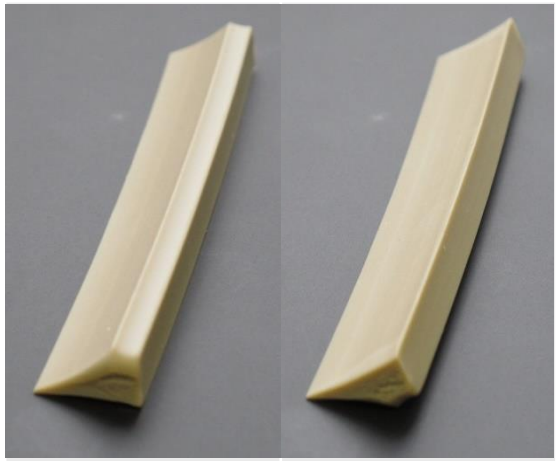


back to diagram

Garvey extrusion - extrudates at 2.0 m/min haul-off speed

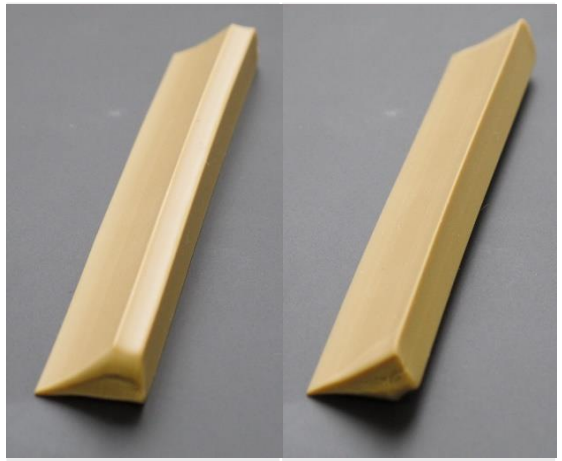
Aktisil Q

front | back



Aktisil PF 777

front | back

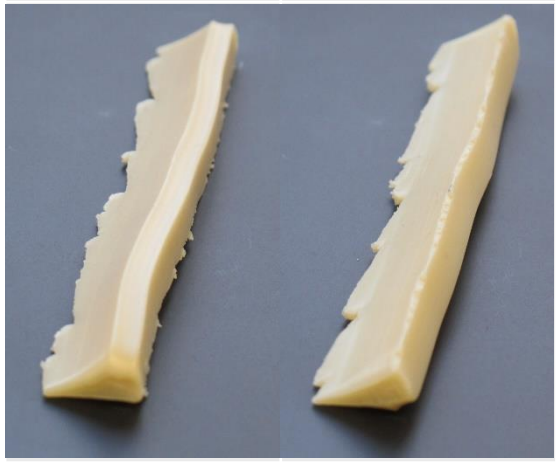


Carbon black N 550

front | back

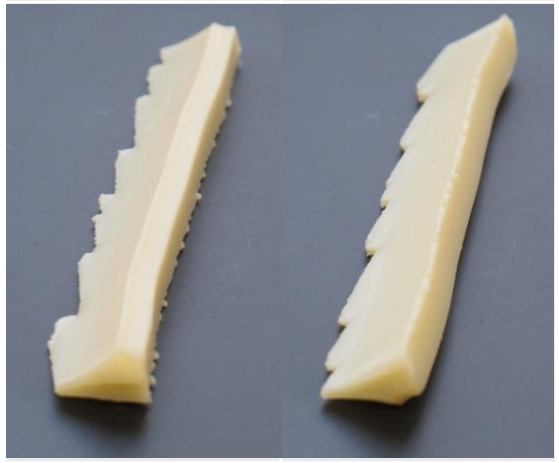
Pptd. silica 180 m²/g

front | back



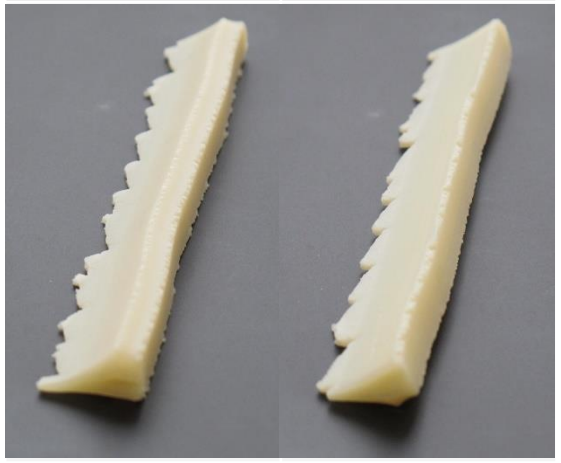
Pptd. silica 180 m²/g with DEG

front | back



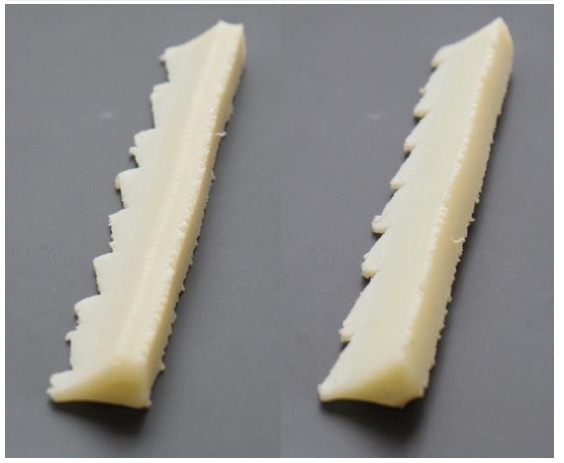
Pptd. aluminum silicate

front | back



Pptd. aluminum silicate with DEG

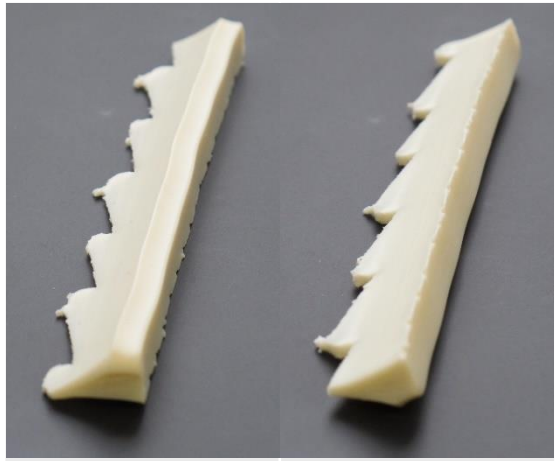
front | back



Garvey extrusion - extrudates at 2.0 m/min haul-off speed

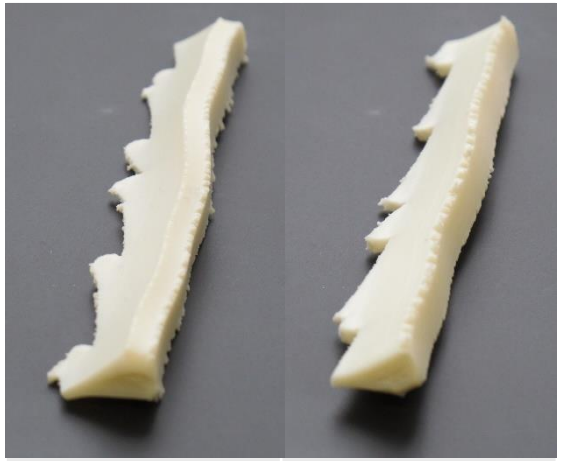
Pptd. calcium silicate

front | back



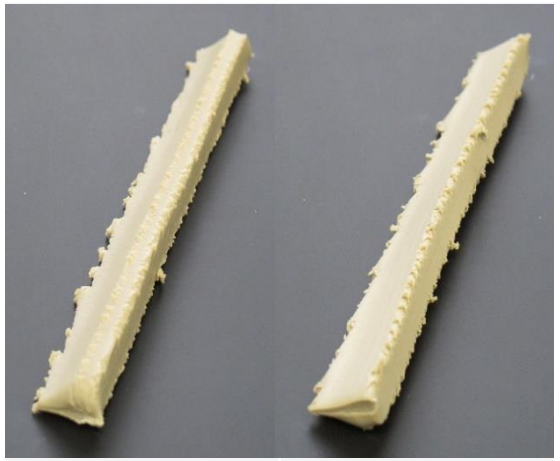
Pptd. calcium silicate with DEG

front | back



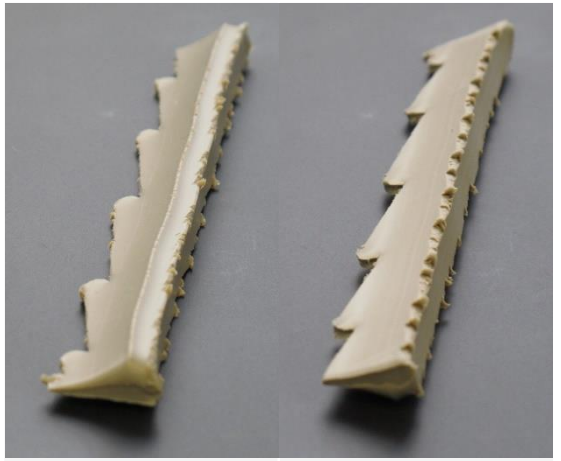
French Hard Clay with DEG

front | back



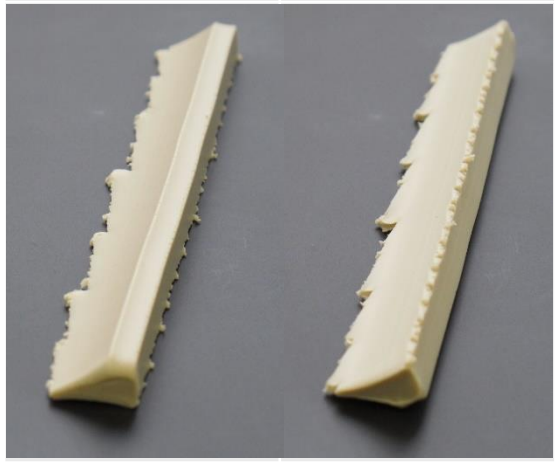
Engl. Hard Clay with DEG

front | back



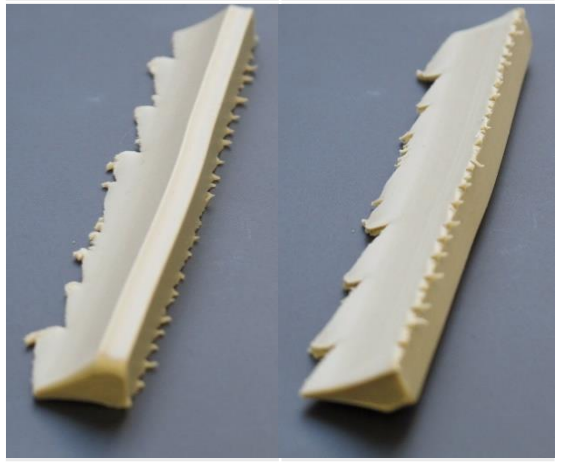
Engl. Clay with DEG

front | back



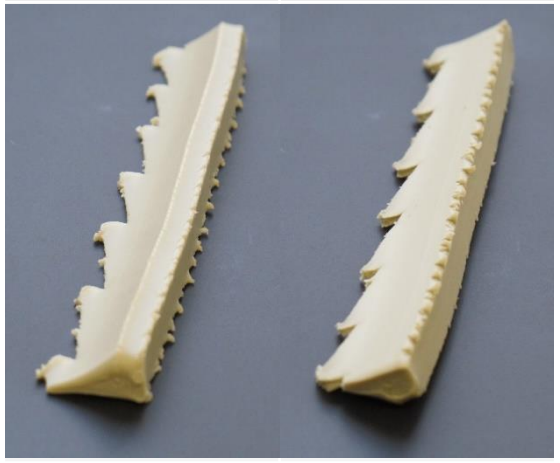
Engl. Soft Clay

front | back



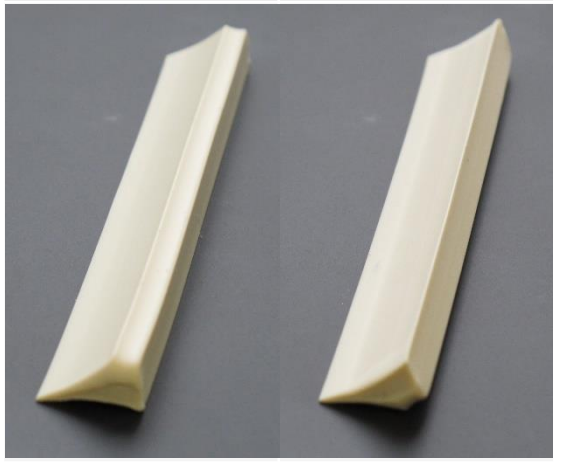
Engl. Soft Clay with DEG

front | back



Engl. calcined Clay

front | back

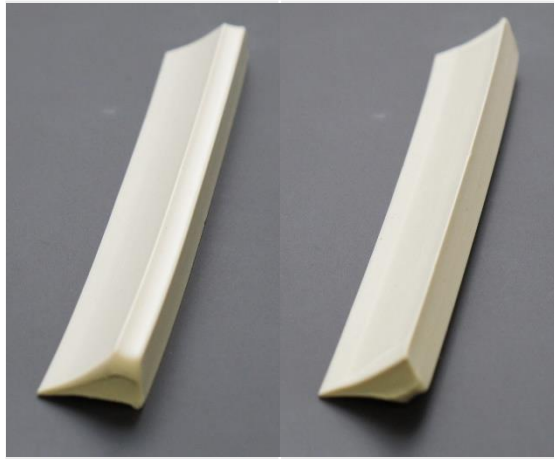


back to diagram

Garvey extrusion - extrudates at 2.0 m/min haul-off speed

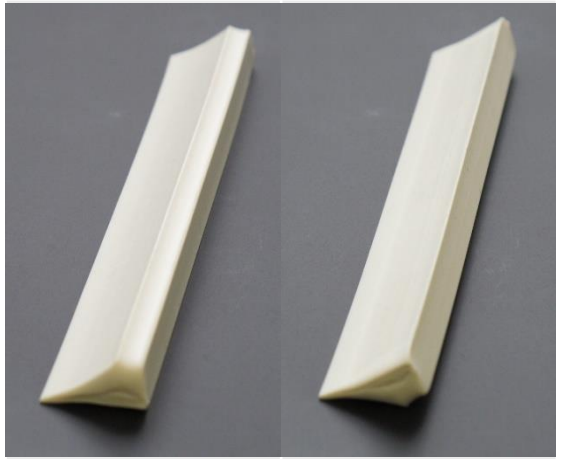
Americ. calcined Clay

front | back



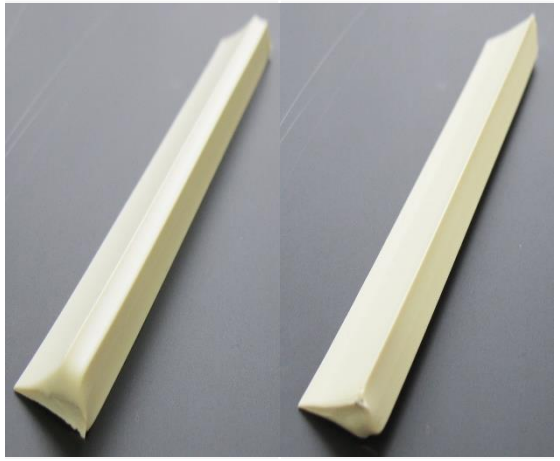
Americ. calcined Clay, vinyl functio. (T)

front | back



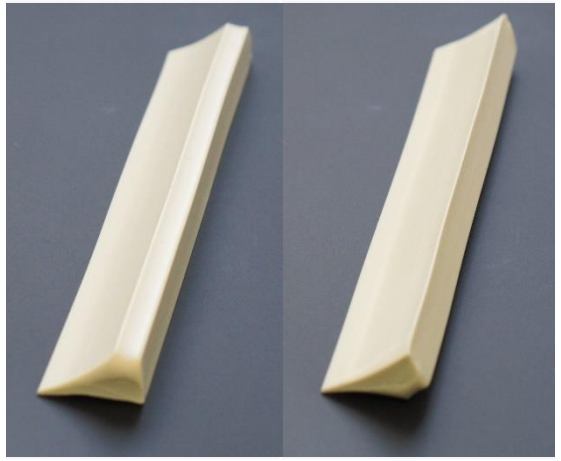
Americ. calcined Clay, amino functio.

front | back



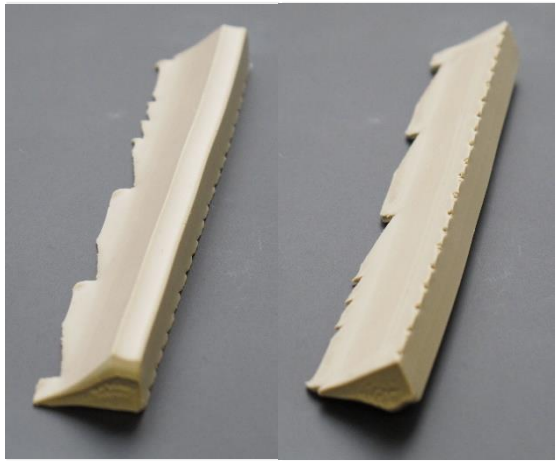
Americ. calcined Clay, vinyl functio. (B)

front | back



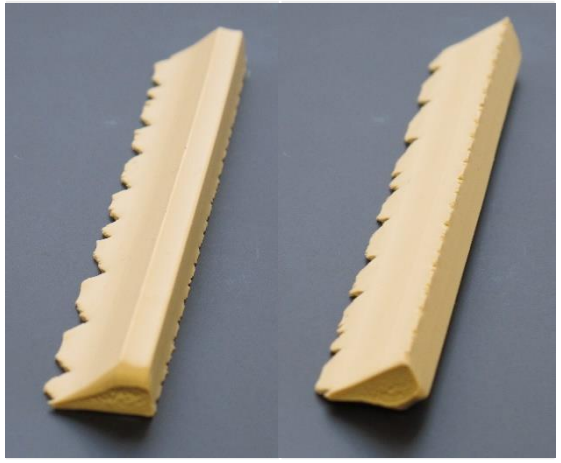
Whiting

front | back



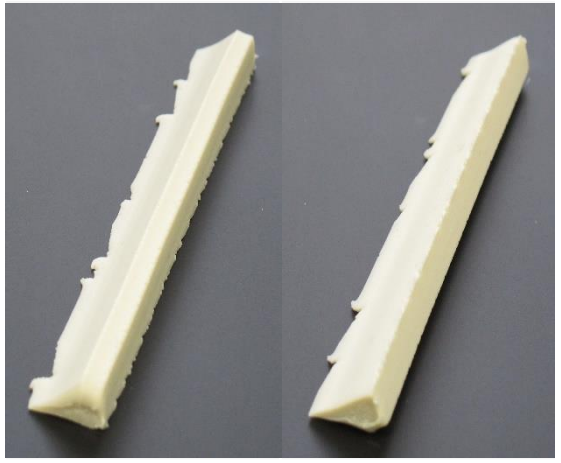
Whiting, stearate functio.

front | back



Americ. Talc

front | back



Americ. coated Talc, amino functio.

front | back