Multidisciplinary investigations on coupled rockwall-talus-systems (Turtmann Valley, Swiss Alps)

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PROBLEM STATEMENT

Why study rockwall-talus-systems?

ROCKWALL
- → Initial **source of sediment** in hillslope sediment cascade [1]
- → Rock mechanical, hydrological and thermal characteristics control **spatio-temporal efficiency of rockfalls** [2, 3]
- → Control on **sediment flux and storage**

TALUS
- → **Major sediment storage** in mountains [4]
- → **Indication for rockfall activity** (i.e. block size, timing, volume) and bedrock instability [5, 6]

AIM Characterisation of rockfall efficiency (i.e. block size, shape) for long-term rockwall erosion and talus slope deposition.

STUDY AREA

In the **Turtmann Valley** (South Swiss Alps), **two rockwalls and corresponding talus slopes (RT1 and RT2)** were investigated (red square: Hungerlihorn, **Fig. 1**).

Rockfall deposits account for 1/8 of debris volume stored in all hanging valleys [7]. RT1 and RT2 lie in **probable permafrost area** [8].

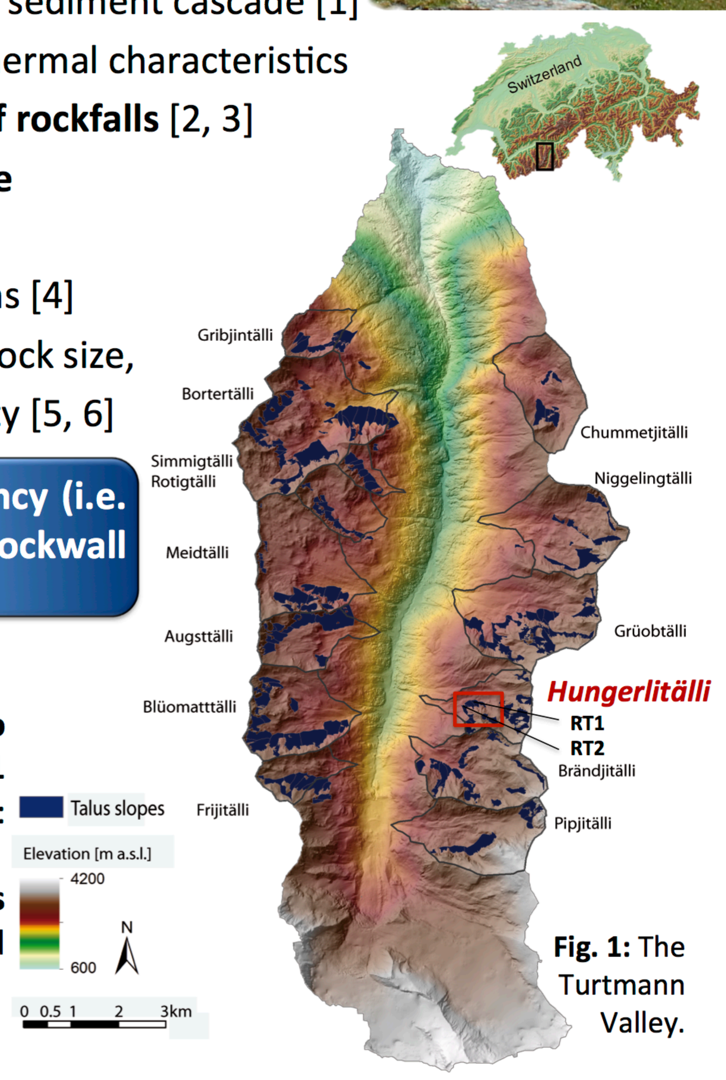

Fig. 1: The Turtmann Valley.

METHODS

How to investigate rockwall-talus-systems?

ROCKWALL
- **Electrical Resistivity Tomography** (ERT) and **Seismic Refraction Tomography** (SRT) along 40-50m transects with 1-1.25m electrode and geophone spacing (**Fig.2**).
- **Geotechnical surveys of discontinuities** [9] and **rock mass strength** (**RMS,** [10]) along scanline *S3, S4, S9.*

Fig.2: ERT at eastern rockwall 2.

Fig.3: SRT at talus 1.

TALUS
- **ERT and SRT** along 150-200 m transects with 5m electrode and 4m geophone spacing (**Fig.4**).
- Every 25m **block size and shape mapping** (a, b, c axis) in 5x5m plots [11].

MAJOR OUTCOMES

I. Rockfall size and shape depend on geotechnical rockwall properties
- → Small spacing, short persistences, Paragneiss → small, flat, elongated blocks
- → Large spacing, long persistences, Amphibolite → large, spherical blocks

II. Rockfall process behaviour is reflected in talus block characteristics
- → Downslope increase of block sizes and sphericity → large kinetic energy of rockfalls
- → Small and flat particles at the talus' apex → near surface weathering of rockwalls

III. The local existence of bedrock permafrost cannot be validated
- → No permafrost influence on rockwall stability
- → Unidirectional freezing at near-surface as effective breakdown mechanism [14]

ROCKWALL-TALUS SYSTEM 1 (RT1)

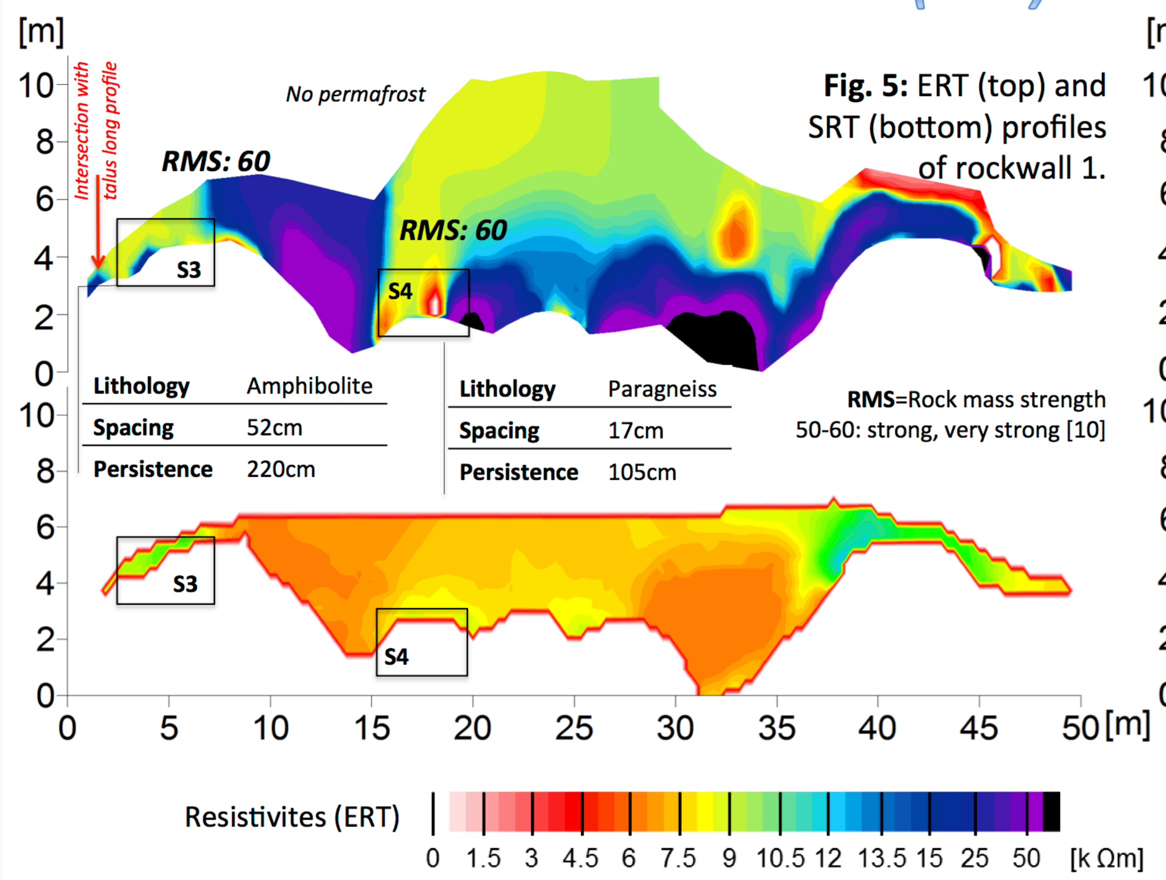

Fig. 5: ERT (top) and SRT (bottom) profiles of rockwall 1.

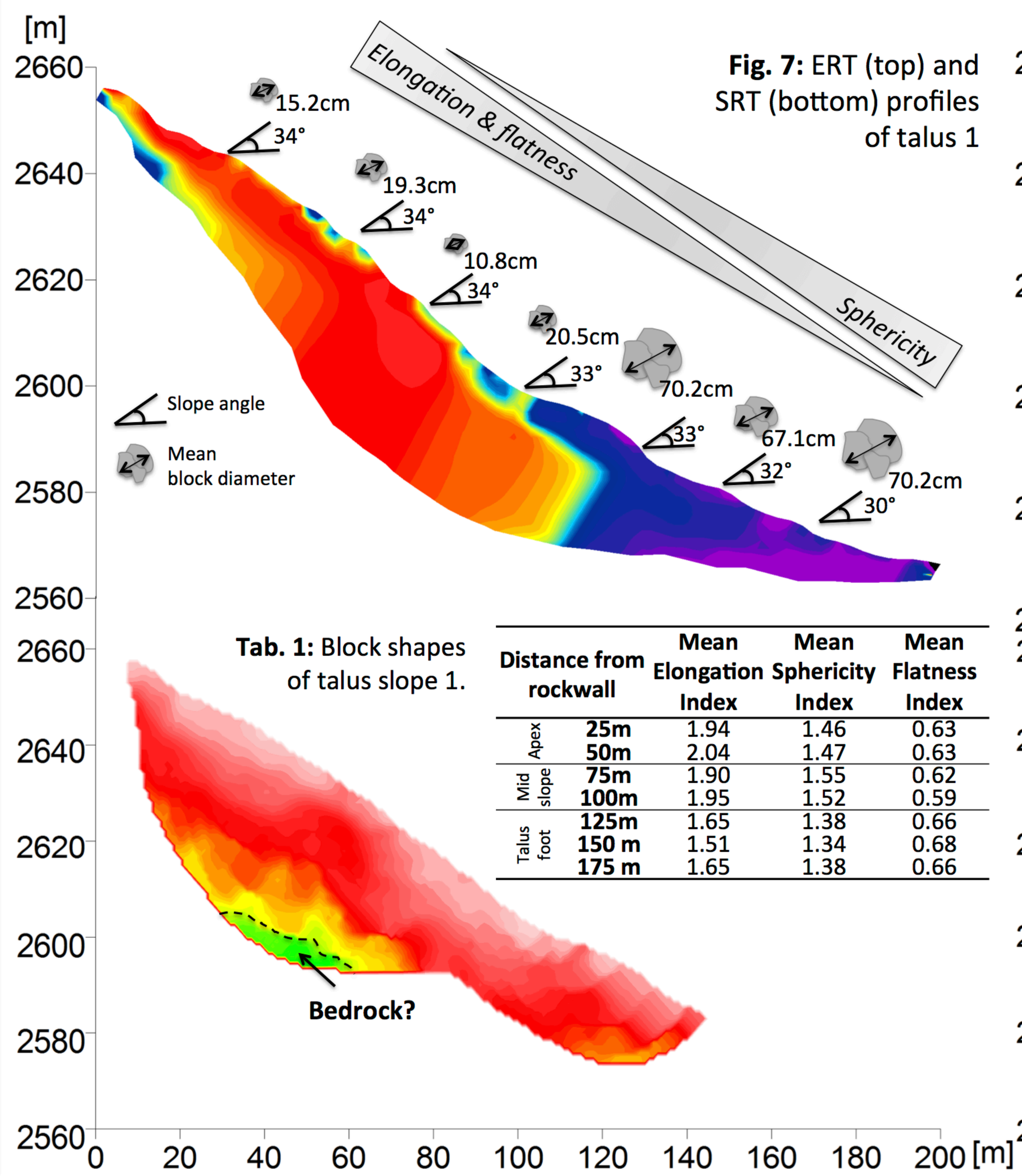

Fig. 7: ERT (top) and SRT (bottom) profiles of talus 1

Tab. 1: Block shapes of talus slope 1.

	Distance from rockwall	Mean Elongation Index	Mean Sphericity Index	Mean Flatness Index
Apex	25m	1.94	1.46	0.63
	50m	2.04	1.47	0.63
Mid slope	75m	1.90	1.55	0.62
	100m	1.95	1.52	0.59
Talus foot	125m	1.65	1.38	0.66
	150 m	1.51	1.34	0.68
	175 m	1.65	1.38	0.66

ROCKWALL-TALUS SYSTEM 2 (RT2)

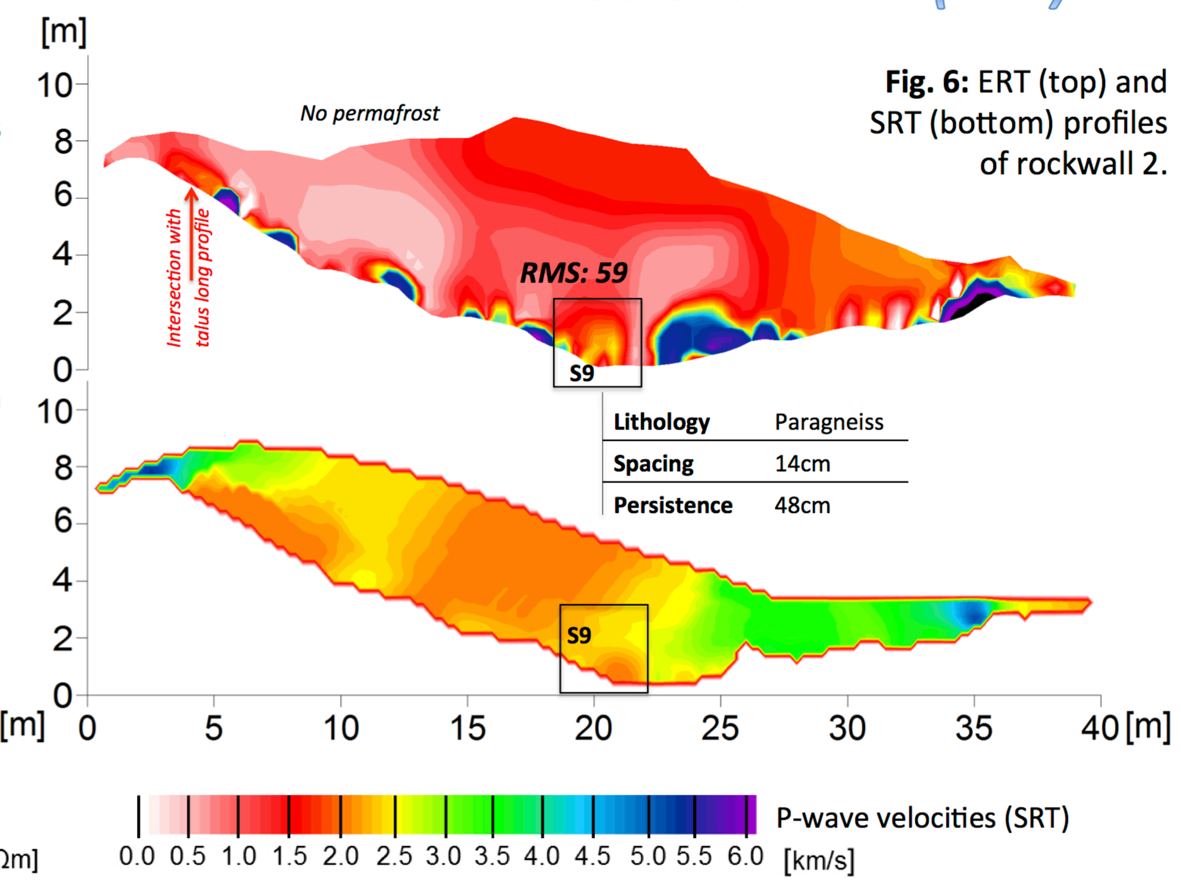

Fig. 6: ERT (top) and SRT (bottom) profiles of rockwall 2.

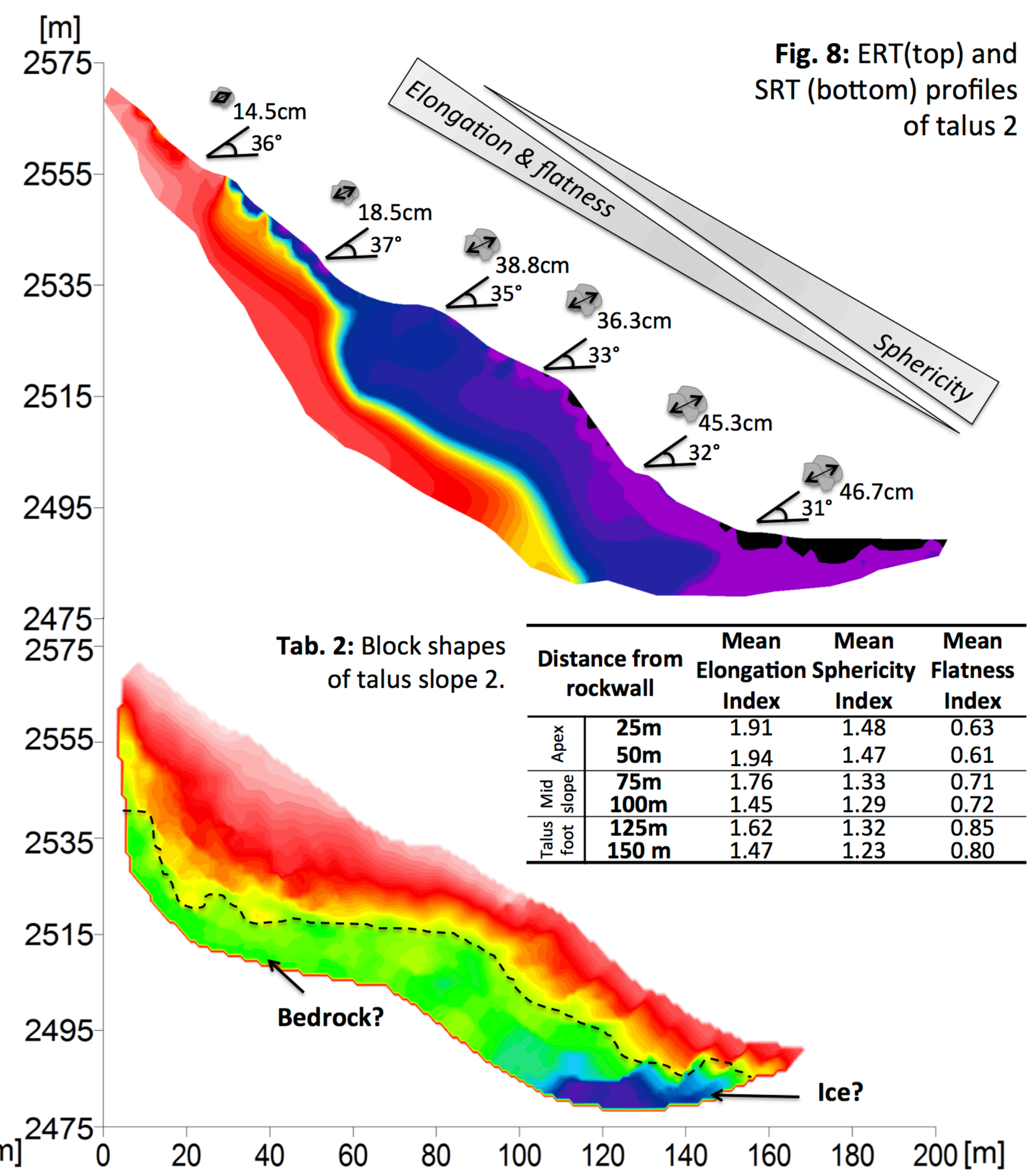

Fig. 8: ERT(top) and SRT (bottom) profiles of talus 2

Tab. 2: Block shapes of talus slope 2.

	Distance from rockwall	Mean Elongation Index	Mean Sphericity Index	Mean Flatness Index
Apex	25m	1.91	1.48	0.63
	50m	1.94	1.47	0.61
Mid slope	75m	1.76	1.33	0.71
	100m	1.45	1.29	0.72
Talus foot	125m	1.62	1.32	0.85
	150 m	1.47	1.23	0.80

ERT, SRT & GEOTECHNICAL SURVEYS OF ROCKWALLS

High resistivities (>10k Ωm) and **high p-wave velocities** (> 3km/s) (**Fig.5**) seem to correlate with **dried bedrock** consisting of **Amphibolites** (*S3*, **Fig.10**) with large **joint spacing** (52cm, *S3*) and **long persistences** (200cm, *S3*). In both rockwalls, **no permafrost** could be found (>5.3km/s would be expected for permafrost [12]).

Fig.10: Eastern part of rockwall 1 at scanline S3.

Fig.9: Western part of rockwall 2 (S4).

Lower resistivities (<6k Ωm) and **low p-wave velocities** (<2.5km/s) (**Fig. 5,6**) seem to be linked to **small joint spacing** (14-17cm in *S4, S9*), **short persistences** (48-105cm) and **Paragneiss** (**Fig.9**).

ERT, SRT & BLOCK SIZE MAPPING ON TALUS SLOPES

Fig.11: Block mapping at the foot of talus 1.

High resistivities (>13.5k Ωm) and low p-waves (500m/s) at the talus foot (**Fig.7,8**) are linked to **large blocks** with mean **diameters of 67-45cm (Fig.11)** resulting in **high porosity** and **dry material. Low resistivities (<6.5k Ωm) and low p-waves (500m/s)** at the apex (**Fig.7,8**) are linked to **patches of fine, wet sediments** (initial soil and plants) **(Fig.12)**.

Fig.12: Small grain sizes at the apex of talus 1.

Bedrock depth was found **at ca. 10-30m** (compare to 15.5-28.8m [13]) in both talus slopes. In RT2, SRT points to **possible ice at the talus foot.** In comparison, talus1 is characterised by **larger, more spherical blocks of Amphibolite (Fig.7, Tab.1)** than talus2, where block are **smaller and flatter (Fig.8, Tab.2).**

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