



Albula line (Thusis – St. Moritz)

| 6 | 5 | |
|---|---|--|
| | | |

Kilometre markings

| Station | Altitude |
|--------------|----------|
| Thusis | 697.2 |
| Sils i.D. | 735.2 |
| Solis | 850.7 |
| Tiefencastel | 883.7 |
| Surava | 939.1 |
| Alvaneu | 999.3 |
| Filisur | 1,080.2 |
| Stugl/Stuls | 1,276.5 |
| Bergün | 1,372.3 |
| Muot | 1,575.1 |
| Preda | 1,788.7 |
| Spinas | 1,814.7 |
| Bever | 1,710.2 |
| Samedan | 1,705.4 |
| Celerina | 1,729.7 |
| St. Moritz | 1,774.7 |
| Pontresina | 1,773.7 |

Core zone

Core zone with railway and cultural landscape

Buffer zone

- Buffer zone in the near area
- Buffer zone in the distant area (backdrop)
- Horizon line

Other contents

Other stretches of the Rhaetian Railway

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2.a.3 Descriptions of sections

Albula line (Thusis – St. Moritz, built 1899 – 1904)

The Albula line, which connects the towns of Thusis and St. Moritz, was built between 1899 and 1904. It was planned primarily to meet the needs of the rapid growth in tourism in the Upper Engadin, which began in the middle of the 19th century (cf. 2.b.9). In terms of its functions it can be described as a branch terminal line; in contrast to a through line it did not connect two outlying conurbations but linked the population of a valley (in this case an inner-Alpine valley) to an interregional railway network and did not itself have any continuing connection. However, as far as the alignment is concerned the Albula line can be classed as a trans-Alpine mountain railway in the same tradition as the Semmering and Gotthard railways. In terms of operational management and rolling stock the Albula line was based on the major through-lines, although the Albula line differed from these as it was narrow-gauge and not standard-gauge, had tighter curve radii, and a maximum gradient of 35 ‰ as opposed to a mere 25 ‰.

Standards

The Albula line was part of a larger Rhaetian Railway construction programme (cf. 2.b.5), which also included the line through the Rhine gorge, from Reichenau to Ilanz; the design standards and execution of the two lines are identical. The determination of specific set values was necessary so that the alignment of the line could be plotted and the costs calculated. Such values included maximum gradient, minimum curve radius, track gauge, formation width and the loading gauge. Standards and types for other features were also defined for the Albula line with respect to station buildings (cf. 2.a.5), stone arch bridges and walls, the angle of slope of embankments and cuttings, and details such as the design of fences. Norms were also prepared and developed for the quality of construction of the buildings. Documents defining staff responsibilities for the railway personnel were published before the line was commissioned. From section engineer to tunnel guard, every employee was required to comply with a personalised set of rules. All this shows the determination of those responsible to construct a railway line which would be exemplary in every detail.

- > Track gauge 1,000 mm
- Curve radius minimum 120 m, in exceptional cases 100 m
- > Maximum gradient Thusis Filisur and Bever – St. Moritz 25 ‰
- > Maximum gradient Filisur–Bever 35‰
- > Width of formation 3.8 m 4.1 m
- > Passing length 120 m, after 1904 gradually increased to 200 m, today minimum 270 m
- > Railway loading gauge 3.55 m width, 3.9 m height
- > Angle of slope of embankments and cuttings 2:3
- > Taper of mortar masonry: 1:5
- > Taper of dry masonry: 1:3

Longitudinal profile, route planning

The original alignment of the line – still largely followed by the Albula line today – was developed based on the specific principles for a main line: as such a line should arrive at its destination as efficiently as possible, a balanced longitudinal profile was to be aimed for. "Lost" upgrades, for example to bring a station closer to a village or to avoid obstacles, were avoided. The overall line can be roughly divided into



Albula line > Profile of the line. Enzyklopädie des Eisenbahnwesens, ed. by [Victor] von Röll, vol. 1, Berlin and Vienna 1912.

three sections: a long northern ramp, the summit tunnel, and a short southern ramp with a following valley section. The northern ramp for its part consists of two ramps, each with an upgrade of 25% (Thusis-Lochtobel and Surava-Filisur) and a third (main) ramp with a 35% downgrade (Filisur-Preda). This division of the northern ramp into a section with a low gradient and a section with a higher gradient points to the efforts which were made to design the railway line with the aim of keeping operational management as economic as possible: up to Filisur the line could be operated with a less powerful steam locomotive. It was only for the second section that it was necessary to involve the use of a more powerful or a second locomotive; for technical reasons the journey had to be divided into stages when the services were steam-operated.

With a mountain railway, keeping to a balanced longitudinal profile necessarily involves the building of many civil engineering structures. In this respect, four sections of the Albula line can be identified which have a high density of engineering structures:

- > Thusis-Tiefencastel (Schin gorge)
- > Surava–Preda (Albula valley)
- > Spinas-Bever (Bever valley)
- Celerina–St. Moritz (Charnadüra valley stage)

With the exception of the section Sils i. D. (Sils im Domleschg)–Solis the line runs along the sunny side of the valley; this is an advantage in terms of snow clearance and drainage. With regard to snow clearance the formation width along revetment walls was widened in order to provide space for the cleared snow on the mountain side of the line. Where accumulations of snow were to be expected the line was either set on an embankment or snow trenches were excavated.

Special elements of the layout are the forced align-

ments between Alvaneu and Preda; these include exits from side valleys and loops with turning tunnels und spiral tunnels. A typical aspect of the alignment as a main line is that all the crossings with main roads (with the exception of those in Surava and Samedan) were built as overpasses or underpasses. There are still many level crossings with farm tracks.

Organisation of the intermediate stations

A number of intermediate stations have been constructed along the Albula section between the two termini in Thusis and St. Moritz, and these too have a standardised configuration. At the smaller stations the main track, which is used by the through trains, has a straight and level length of 230 m. The passing track which branches off from the main track allows trains to pass and also provides access to the loading ramp, which has a useable length of 200 m and at one end (mostly against the downgrade) extends into a dead-end track. The typical intermediate station therefore has a total of three points. The station building is situated close to the passing track, and always where the deadend track branches off. This track is paralleled on one side by the loading ramp. A station forecourt was constructed at the other end of the building (which contains the waiting room); the forecourt was also the start of the station access road. Grouped around this forecourt were a station toilet, a well and the station master's garden. The larger intermediate stations – Tiefencastel, Filisur, Bergün/Bravuogn, Bever and Samedan were equipped with more extensive track systems, such as sidings, and tracks leading to the water tank, the engine shed and the turntable. For technical reasons a longer intermediate halt was constructed in Filisur, which is about the middle of the section. Here there was also a station buffet which offered travellers light refreshments. There



Albula line > Alignment below the ruins at Campi near Sils i.D. R. Bösch/Rhaetian Railway

was no freight traffic at any of the intermediate stations on a scale that merited the construction of special facilities.

Short description of the individual sections of the route.

The description of the individual sections of the line and the various structures associated with them is based on the kilometerage specified at the time the Rhaetian Railway was built and which is still in use today. Kilometre 0.0 of the Rhaetian Railway's network is in Landquart.

km 41-64: Thusis-Filisur

The starting point of the Albula line is the station in Thusis. This was built as the terminus of the line between Chur and Thusis, opened in 1896. The station facility was completely rebuilt between 1990–1993.

Directly following the station in Thusis the line crosses the Hinterrhein (Upper Rhine) over a wide-spanned concrete bridge (km 41.7). The original crossing – an iron lozenge lattice girder with a span of ca. 80 m – had to be replaced when the motorway was constructed. Even in its original form as an iron structure the Rhine bridge formed an untypical element among the otherwise "stone-built" engineering structures of the Albula line; here formal reference to the river bridges over the Rhine was made for the last time, before the line enters the mountains (cf. 2.a.4). The former Rhätischen Werke's Viamala power station can be seen from the bridge. It is from this power station that the Rhaetian Railway drew the electricity needed for the operation of the railway, beginning with the electrification of the line in 1919 and on up to the middle of the 20th century (cf. 2.b.7).

Starting as far up the line as Thusis the alignment is determined by compliance with the maximum

slope of 25‰ and by the requirement for a balanced longitudinal profile. At km 42.6, close to Ehrenfels castle, the line crosses the historic Viamala bridleway over a small, three-arched underpass. The first of the smaller intermediate stations is reached at the station in Sils i.D. (km 43.1). From here a connecting road roughly 100 m long leads down to the cantonal highway; the village at the foot of the slope which gives the station its name can be reached by means of small path. A branch line on the Thusis side serves to load the broken stone from the gravel plant on the Albula. The track scales in the dead-end track – untypical for a small railway station - recall the significant volume of freight traffic once dealt with in Sils i.D., here, and not in Thusis, was where the freight handling for the industrial factories along the Albula took place.

At the end of the Sils i.D. railway station the road, which ran along below the line to this point, crosses the tracks on a bridge; from here it now continues to run above the line. After this underpass the line of the railway was blasted out of the rock. The railway line enters the Schin gorge along a sharp curve. At the entrance to the gorge, stand the ruins of Campi castle; given its unplastered rubble masonry the question involuntarily comes to mind of to what extent did the builders of the railway line base the design of the engineering structures on the medieval military architecture typical of Graubünden. The next section, as far as the station in Solis, is distinguished by a continuing series of tunnels, inclined viaducts, bridges and walls. The total of twelve tunnels on this section have altogether a length of 4,270 m, which corresponds to half the length of the Schin section of the line; structures which have significant lengths include the Runplanas (km 44.8), Versasca (km 45.5) Passmal (km 47.1) and Solis (km 48.2) tunnels. The bridge structures



Albula line > The Solis Viaduct, the bridge with the greatest span on the Albula line. P. Donatsch



Albula line > The 27 m Mistail Viaduct is located immediately below the Carolingian church of St. Peter in Mistail at the upper end of the Schin gorge. B. Studer

which should be mentioned include the Bändertobel viaduct (km 47.0), the Lochtobel viaduct (km 47.8), which used to be very popular as a subject for photographs, but is overgrown today, and the Muttnertobel viaduct (km 48.2). The first, 25‰ steep section of the northern ramp ends at the Lochtobel viaduct; a horizontal section commences directly after the bridge and extends as far as the Solis viaduct. Apart from the Solis viaduct, the Muttnertobel viaduct has the widest spanned single arch of all the bridge structures on the Albula section. It leads directly into the Solis tunnel; at the southern portal a switch house dating from the time when the line was electrified (1919) has been preserved. Immediately after the tunnel the line runs directly into the station in Solis (km 49.3), which approximately marks the midpoint between Sils i.D. and Tiefencastel. The reason for the construction of this station was less to serve a village but rather the opportunity to provide the essential facility of a passing track - due to the very difficult topography in the Schin – at the first feasible location after Sils i.D. The restricted space available is the reason why Solis is the only station on the Albula line which was not built to a straight alignment but along a reverse curve.

Shortly after the station at Solis the railway line crosses over the Solis viaduct (km 49.8), the bridge has the greatest arch span of any structure on the Albula section. The crossing of the valley at a right angle called for curved approaches; these lie partly on approach bridges and allow travellers a view of the imposing viaduct. The exceptionally well-maintained Solis viaduct can be easily accessed and, thanks to the good view of it from the bridge of the old cantonal highway running parallel, is a popular motif for photographs. With the Solis viaduct the railway switches from the shady side to the sunny side of the Albula valley. For topographical reasons it was only possible to cross the valley at this specific point; thus the Solis viaduct is a defining element which influenced the entire the alignment between Thusis and Tiefencastel.

After the Solis viaduct the second section of the northern ramp begins, with an upgrade of 25 %. The section as far as Tiefencastel has a high density of engineering structures, above all of tunnels passing behind rock faces. Between the Alvaschein and the Nisellas tunnels (km 50.8 and 51.5) there is an improvised worker's accommodation building, located under the arch of a bridge (km 51.5); the accommodation is linked to the maintenance of the railway. The address, "At the Golden Ox 1963", provides an indication of when it was constructed. At km 51.8 there are footings of a linesman's house; this point, which later saw the construction of the Nisella block post, was where the original plans proposed the construction of a railway station (Alvaschein). The remains of a cable railway have also been preserved here. This served the construction and maintenance of the former storage dam for the Albula power station (1910). The 27 m long Mistail viaduct at km 52.7 lies directly below the Carolingian church of Mistail; here the rock was cut into to allow its construction. The Tiefencastel railway station (km 54) was built - against the will of the local community – on the opposite side of the valley to the village of the same name, where it lay close to the main road; this was a result of crossing the valley at Solis and the more important function given to the railway as providing a connecting link for the Engadin valley. One interesting feature is the express buffet dating from 1958, the interior of which is furnished in the style of an American "diner" with bar and booths. The following section of the line as far as the Tiefencastel tunnel (km 55) runs through geologically very difficult



Albula line > Alignment in the Albula Valley. D. Enz



Albula line > Zalaint Tunnel and Landwasser Viaduct. Foto Geiger

terrain. As an exception, in order to avoid constructing tunnels here, the normal curve radius of 120 m was reduced to 100 m, so that the railway line, with inclined viaducts and cuttings, could match the terrain more closely. In this area, which is subject to landslides between the Tiefencastel tunnel-the only mountain tunnel between Mistail and the Landwasser viaduct - and the station in Surava (km 58.1), the railway line runs through open terrain, through meadows and bush-covered countryside. Surava railway station lies above the village of the same name. At the edge of the station the line crosses the valley road over a level crossing; the barriers could therefore be operated by the station master himself, so that there was no need to construct a special guard's cottage. At km 59 the railway line leaves the valley floor and begins to climb steadily up the side of the valley as far as Filisur (km 64.4) at a gradient of 25 ‰. This section along the hillside is distinguished by a large number of engineering structures. Typical here is the location of the line on an earth fill embankment which is supported by a dry stone wall. This arrangement avoids the need for high retaining walls in steep terrain, which could only have been constructed in mortar masonry. Between km 60.1-60.3 a protective rockfall walling separates the line on the mountain side from a quarry dating from the time when the line was constructed. The formation level of the station for the next station, in Alveneu (km 60.8), could be set up by means of an embankment, without any walls. The link road between Alvaneu Bad and Alvaneu Dorf was built at the same time as the railway; this road crosses the railway line at the railway station.

The section in the Landwasser valley (km 61.1– 63.4) is the most famous section on the Albula line; it is distinguished by an ensemble of forced alignments. Engineering structures here include

the Schmittentobel viaduct (km 62.6), the Zalaint tunnel (km 62.8), the Landwasser viaduct (km 63.0), the Landwasser tunnel (km 63.1) and a sparing arch viaduct (km 63.4). Travellers have three opportunities to admire the view of the imposing Landwasser viaduct. The Filisur-Schmitten footpath crosses below the Schmittentobel viaduct At km 62 8 the line passes a former railway quarry (on the mountain side). The overgrown piles of stone accumulated here consist of rail track ballast. During the 1920's the rock was excavated above this point and then moved down to the railway line by chutes. The Zalaint tunnel is not lined on the inside, although the portal is marked by a vault arch. Signs of a construction site access can still be recognised around the top of the crag. A site was selected for the crossing of the gorge at the exit of the Landwasser valley where a protruding outcrop allowed the construction of a bridge with a relatively small span. The construction of the Landwasser viaduct (km 63.0) is subject to the demands set by the alignment, whereby the viaduct sets off tangentially from the north slope and then swings in sharp curves - the curve radius here is reduced to 100 m for the second time since leaving Thusis - frontally towards the opposing vertical rock face. The Landwasser viaduct is actually a turning viaduct similar to the

"Kalte Rinne" of the Semmering line. The surrounding terrain has preserved traces of the extraction of material for the viaduct and of the engineering installations. The mine chambers integrated in the foot of the column, so it could be demolished quickly in the event of a military emergency, have since been walled up but they are still recognisable. Since it was opened, this valley crossing has provided an instantly recognisable image of the Albula line. Early standard motifs were the view of the viaduct with the



Albula line > Landwasser Viaduct. The Landwasser Valley is crossed at the narrowest point with a radius of only 100 m. P. Donatsch



Albula line > The Stulsertobel Viaduct is one of the most striking viaducts between Filisur and the Bergünerstein. T. Keller



Albula line > The remote Stuls/Stugl crossing station is built on an outcrop high above the valley. T. Keller

Schmittentobel viaduct in the foreground, or the view from the outer side of the arch. Today perhaps only the view from the former quarry looking down onto the viaduct is well-known.

Km 64–86: Filisur–Albula Tunnel

The decision to gain height as quickly as possible and to leave the valley floor after Surava resulted in the Filisur railway station location high above the village. The station lies on an impressive level area; on the mountain side it is terminated partly by a revetment wall, partly by an earth slope and partly by in-situ rock. Filisur was a stage between Chur and St. Moritz, where the railway engines were checked, and where a buffet was available for the travellers. The station square was planted with a line of trees to underscore the importance of the facility. Access was provided by a new road leading off the cantonal road, and by a new, direct footpath.

The branch line to Davos was opened in 1909, and it is thanks to this line that Filisur is still today a railway station used by fast trains. The conversion of the railway station in 2004 left the depot with its turntable, shed and water crane untouched. The third section of the northern ramp begins after Filisur; the design of the alignment was based entirely on the desire to gain height and used the maximum gradient, which here is now 35 % rather than 25 ‰. This approach led to the need for several engineering structures. Above Filisur railway station the line passes through the 698 m long Greifenstein tunnel (km 65.4) and the short, 55 m Schlossberg tunnel (km 66.2) which form a first reverse loop designed to gain height. The names of these two tunnels are taken from Greifenstein castle which lies above them. This Greifenstein loop is inset in the karst countryside and offers fascinating views back towards the Albula valley. The line then runs along the wooded slope

around 150 m above the valley floor. Here screes alternate with steep rock faces. The section runs continuously along slope sections or in tunnels and on bridges, and may be compared with the part of the Semmering line which runs through the Weinzettelwand. Moving on up to the Bergünerstein the line crosses over eight viaducts (total length 316 m) and through eleven tunnels with a total length of 1,806 m. Where the line runs in the open it is supported almost everywhere by dry stone walling on both the valley and the mountain sides, the walls having an average height of 4 m. The entire section as far as the Bergünerstein is endangered by rock falls. This made it necessary to construct an unusually large number of protective structures; in some parts these extend several hundred metres up the slope and need constant extension and maintenance. The lower portal to the small Cruschetta tunnel (km 67.2) has a rockfall gallery with rockfall catch areas. The abutment on the valley side is structured as a buttress, which is connected to a domed passage. The upper portal is extended by the addition of a rockfall gallery in reinforced concrete. Two notable viaducts are the Surmin (km 68.5) and the Stulsertobel (km 69.7). The latter is joined directly by a vertical retaining wall. With the exception of the cantilevers on the edging the great area of walling is not subdivided. The passing station in Stugl/Stuls (km 70.2) lies on a natural plateau which was extended by means of rock blasting. With station building, guard house, workers' huts and smaller buildings, a group of buildings has been preserved here that reflect the living conditions along the line. A road constructed by the railway leads up to Stugl/Stuls village; this road largely retains its original form. One minor feature is the overbridge over Stugl/Stuls railway station, which is in the form of a "flying arch" - the only bridge along the Albula line which was built to this principle. The



Albula line > The first elongation to overcome the natural step in the terrain between Bergün/Bravuogn and Preda is set in gently sloping meadows. T. Keller



Albula line > A Rhaetian Railway train in the centre loop above Bergün/Bravuogn. P. Donatsch



Albula line > After passing the revetment wall at Fuegna, the train has come down almost to the valley floor and must start climbing again. Foto Geiger

transverse profile of the section from km70.5-71.4is typical for the Albula line: on the valley side a covered dry stone wall and on the mountain side dry stone retaining walls. The line pierces the rock wall of the Bergünerstein, in almost a straight line, through the 409.5 m long tunnel of the same name (km 71.7). Thereafter the line once more runs close to the bottom of the valley, beside the road (km 72.2), which it had turned away from near Surava. Only 124 m after the Bergünerstein tunnel the railway enters the 333 m long Glatscheras tunnel. This is followed by the Bergün/Bravuogn railway station (km 73.1). Bergün/Bravuogn is the only village between Filisur and the Engadin. Here it was hoped – vainly, as it turned out – that the construction of the railway would provide an impulse for the economic development of the locality; structures which give evidence of this are the arsenal near the station building (the arsenal building is to be converted into a railway museum in the near future) and the Kurhaus Hotel. The railway station is situated somewhat above the village. Access was provided by the construction of a new, tree-lined road linking the Albula road with the station forecourt. The valley floor between Bergün/Bravuogn and Preda has an average gradient of 77 ‰; overcoming this 'step' in the terrain required a complicated longitudinal alignment. The first element is located in the gentle meadow slopes above Bergün/Bravuogn; it consists of a double reverse curve which brings to mind the alignment of the Gotthard railway near Wassen. It was so skilfully integrated into the terrain that only two shorter turning tunnels were needed here. A marble memorial tablet was built into the exterior wall of the church in Bergün/Bravuogn in honour of an engineer named Perbs, who designed the open loops of Bergün/Bravuogn and who lost his life in the Greifenstein tunnel in 1901; the tablet itself can be

seen from the railway (km 73.8). At Val Tuors loop curve (km 75.8) the cutting was constructed using the "English" method with a tunnel and vertical shafts; together with the associated embankment, which is protected by four large drainage trenches, this is one of the most imposing earth structures on the Albula line.

Following a section along the slope and the crossing of Val Tisch, the line arrives at the Muot service station. The Val Tisch viaduct (km 77.9) has an uneven face walling. The arches consist of different types of stone; above Bergün it was difficult to find enough suitable stone material for the bridge structures. Near km 78.3 stands a walled workmen's hut. This was used as accommodation during the construction of the avalanche barrier, and later as a kitchen and canteen for track workers; the open fireplace in the interior of the building is still preserved. Today the hut is used as a private cottage. Between km 78.8–79.1 the line passes the Chanaletta avalanche track, from which it had to be protected by extensive avalanche barriers; the dry stone walling reaches up to a height of 2,300 m above sea level. Because of its steepness the mainstream of the avalanche could not be blocked, and therefore the Chanaletta gallery had to be tunnelled through it (km 79.0). The Muot railway station (km 79.2) is a "signal station" and is not open to the public. For this reason the gradient was not reduced to 0‰, as was the case for stations where marshalling manoeuvres were expected, but only down to 15 %. The station building stands with its axis at right angles to the track. Despite the shady location it was decided to build a garden here as well; this - together with a well - can be found on the side toward the mountain.

Soon after Muot the railway line has almost reached the floor of the valley and now it has to climb again. The selected gradient and minimum



Albula line > The stretch between Bergün/Bravuogn and Preda. The impressive alignment can be best appreciated from the air. T. Keller



Albula line > In the foreground the 11 m high and 59 m long Albula Viaduct I. In the background left, the Rugnux inclined viaduct. A. Badrutt



Albula line > Shortly before Preda station there is a spectacular view back to the mountains flanking the inner Albula Valley. Foto Geiger

radius meant that, in the narrow valley, there was no opportunity to construct an open loop or to swing out into a side valley. The few open valley slopes also had to be avoided, in this case because of the risk of avalanches. For this reason use had to be made - three times - of the most costly artificial alignment feature: the spiral tunnel. 500 m above Muot the line crosses the valley river for the first time, traversing the 59 m long and 11 m high Albula Viaduct I (km 79.8). Directly beyond this it winds its way upwards along the left bank, through the 661 m long Rugnux spiral tunnel (km 79.9). The upper portal of this tunnel is connected to a gallery composed of steel and revetment walls with six cast concrete sparing arches. From the upper portal a view can be obtained backwards towards Muot and the adjoining rock section. With the 95 m long and 29 m high Albula Viaduct II (km 81.2) the railway line once again returns to the right bank, in order to avoid the avalanche endangered slope of Val Rots. There now follow the 677 m long Toua spiral tunnel (km 81.6-82.3) and then the Albula Viaduct III (km 82.5). At km 82.8 the line passes through the Maliera avalanche gallery. On the left bank of the river it describes an open semicircular arc, crosses the river Albula for the last time by the Albula Viaduct IV (km 83.0) and then winds its way upwards through the 535 m long Zuondra spiral tunnel (km 83.2-83.7) to the height needed to be able to pass in a straight line through the open valley of Preda towards the Albula tunnel. The latter two spiral tunnels are located almost one above the other, vertically separated by about 50 m. At km 84.4 the cantonal road is crossed at a sharp angle by means of a straight bridge. The railway crosses the Preda basin over an embankment which was constructed using material obtained from the excavation of the Albula tunnel. Besides the railway structures themselves the density of accommodation buildings along the section just described is also worthy of note; these were used to provide housing for the railway maintenance workers. Between Bergün/Bravuogn and Preda traces can be found of no fewer than four, permanently occupied houses and five huts – for example the guards' huts at the lower portal of the Rugnux spiral tunnel. These were available to the workers whose job was to remove ice from the tunnel in winter.

km 86–92: Albula tunnel

This section consists of the Albula tunnel and the two adjoining stations. The 5,864.5 m long summit tunnel connects the high Preda valley, in a straight line, with Val Bever, a side valley of the Upper Engadin. The tunnel passes below the western peak of the Dschimel; the highest overburden of mountain is around 950 m. From the entry portal the tunnel tube first rises for 100 m at a slope of 5 ‰, with the next 3,070 m rising at 10 ‰; the crest horizontal section then follows; it is 100 m long and at a height of 1,823 m. Finally a 2,596 m long downgrade of 2 % drops down towards the exit portal in Spinas. The clear height is 5 m, the clear width 4.5 m; these dimensions exceed those of the smaller tunnel by 0.3 and 0.2 m. The total clearance is 19.91 m², which is around 86% of the 23.2 m² of the Simplon tunnel. The vault is designed as a semicircle; the abutments have a taper of 1/20. The design of the well-preserved southern portal of the Albula tunnel is a particularly representative feature.

Preda railway station (km 85.7) at the entrance to the tunnel lies in an area which formerly was only used for brief periods; before the construction of the railway the only feature here was the Kulm Hotel on the Albula road. When the railway was constructed Preda became a settlement which was used all year round. It never quite attained the



Albula line > The railway reaches the Engadin at Bever. A. Badrutt



Albula line > Between Samedan and Celerina the River Inn forces the railway and the road to run along the foot of the rocks. T. Keller status of a railway village, since railway operations required the presence of only a few families in Preda. The station is built on material which became available with the excavation of the Albula tunnel. Today Preda is the starting point for the railway history education trail towards Bergün/Bravuogn.

Spinas, at the other end of the Albula tunnel, like Preda, used to be just a summer settlement. Following the construction of the railway only railway workers and their families lived here all year round. The station (km 91.8), probably the best preserved station ensemble on the Albula line, lies partly in the advance cutting and partly on material excavated from the Albula tunnel. Between the Albula tunnel and the Spina railway station the line crosses the Beverin river over a two-track steel bridge.

km 92–103: Spinas–St. Moritz

The last section of the Albula railway line, from Spinas to St. Moritz, runs through quite a different type of countryside to that of the northern ramp. The only engineering structures that had to be built here were two tunnels - the Charnadüra I tunnel (449 m) and the Argentieri tunnel (114 m) – which were needed to take the railway over the gorge of the Inn shortly before St. Moritz, and three small bridges over the river Beverin. There is a risk of avalanches along both flanks of the Bever valley. For this reason the railway line up to Bever was relocated and built on a high embankment along the centre of the valley, parallel to the river Beverin; material excavated from the tunnel was used as the fill material for the embankment. A mortar masonry wall, 150 m long, was built to protect the railway line from the avalanche "da la Resgia" (km 94.2) which, coming from as far as the Crasta Mora on the left flank of the valley, even crosses the Beverin in some plac-

es. Shortly before this wall there is an overbridge with a concrete, skewed segmental arch (km 94.1). At km 94.8 the line crosses the river at a oblique angle by means of a flat stone vault in a curve with open stone masonry. Beyond the bridge the railway line runs along a meadow with abandoned irrigation ditches. The entrance to Bever railway station (km 96.6) is on a curve, the narrow radius is explained by the effort on the one hand to construct the station close to the village, and on the other to be able to construct a branch line towards the Lower Engadin. The road between Bever and Samedan runs parallel to Bever railway station, so that only a short access road had to be built. Despite its closeness to Samedan, Bever railway station had all the facilities to be found in a medium-sized station: station buildings, goods depot, post office (later the station buffet) and two guard's houses. After 1913 the Lower Engadin line to Scuol branched off here and Bever was for a long time used as a transfer station. From 1913 the power supply for the electrical operation was located in Bever; the former transformer building is today a substation.

From Bever to Samedan the line is almost straight, although with some light downgrades. The most impressive structure is the embankment in the valley (km 95.9-96.7), also constructed using material excavated from the Albula tunnel. Samedan railway station (km 97.7) occupies the space between the former high bank of the river Inn and the dyke along the Inn; when the railway was built this area appeared as an stretch of exposed gravel. The station road (today the Via Retica) branches off the road towards Pontresina in front of the railway station and then rises to reach the road towards Bever just after the Hotel Bernina. In addition there are two footpaths which lead from the station into the village. In Samedan the line, opened 1908, branches off towards



St. Moritz > The terminus of the Albula line. A. Henkel/Rhaetian Railway



Between Samedan and Pontresina > A train with a load of timber on its way south through the autumnal splendour of the Engadin. A. Henkel/Rhaetian Railway

Pontresina. The depot facility dates from 1985 and stands on the site of the original depot and workshops. The station building and the railway settlement are also new facilities, constructed on the site of the original buildings. Many railway workers moved to the Samedan area after the railway opened. Between Samedan and St. Moritz the line has to cross a valley; in the section from Ochsenbrücke (km 99.3) to St. Moritz the line therefore rises along the side of the valley at a gradient of 25 ‰. At km 98 the line crosses the Samedan-Pontresina road. From km 98.6 to km 99 the line then runs on an embankment over

the former loop of the river Inn, whilst the old valley road runs to the right, at the foot of the slope. At km 99.2–99.6 there is what used to be a convex bank of the river, where the Inn directly washed against a rock groin. Here, railway line and road squeeze in close to the foot of the rock. On the mountain side the railway is protected against falling stones by rockfall catch areas and barriers.

Celerina railway station is located at km 100.3. The Crasta road overbridge (km 101.4) is a skewed crossing with segmental arches in in-situ concrete. A watchman's hut stands at the lower portal of the Charnadüra tunnel (km 101.9–102.4); it may have served as accommodation for workers who had to remove ice from the tunnel in wintertime.

At km 102.9 the line reaches St. Moritz railway station, the end of the Albula railway. The selection of the location for the St. Moritz railway station was the subject of some controversy (cf. 2.b.4 and 2.b.6), and was the reason why it was only possible to open the Celerina–St. Moritz section in 1904 and not in 1903 as planned. The selected – peripheral – location eventually turned out not to be the ideal site. The station formation was achieved on the mountain side by the construction of a high revetment wall with sparing arches, and on the lake side by the construction of an embankment. A road ran along the side of the lake towards St. Moritz Bad, and another, today's Via Serlas, into the village. The track system consists of the two separate railway stations for the Rhaetian Railway and the Bernina Railway. The original facilities of the Rhaetian Railway – largely preserved in the existing railway station today – were those of a through station, with ramp track, three marshalling tracks and a siding. The station was equipped appropriately with a view to an extension of the line to Chiavenna, then planned.

km 98–103: Samedan–Pontresina, opened 1908

The connecting line to Pontresina branches off at the exit from Samedan railway station and following a left-hand curve crosses the river Inn by means of a steel bridge. The Champagna plateau is then crossed in a straight line which continues as far as today's railway halt in Punt Muragl (km 100.5), from where a footpath leads to the cable railway to Muottas Muragl, which was opened 1907. Punt Muragl was originally a full passing station with linesman's hut. The alignment of the section from Punt Muragl to Pontresina was designed with an upgrade of 20‰. Following the halt the line displays a large number of engineering structures: an underpass below the main road, a steel bridge over the Flazbach, a paved foot embankment above the level of the plateau, hillside alignment with cut into the rock, all in a reverse curve loop. Pontresina railway station (km 103.0) lies opposite the village and is connected to it by means of a link road. The station building is the largest on the Rhaetian Railway.

The Rhaetian Railway has been marketing a brochure with artistic panorama photographs of the narrowgauge network in Graubünden since the 1930s. The following illustrations are taken from a new edition issued in the 1950s. Collection: G. Brüngger





Chur > Sils i.D.



Sils i.D. > Bergün/Bravuogn

Bergün/Bravuogn > Preda (Albula Tunnel)



Spinas > Bernina Pass

Bernina Ospizio > Tirano (I)





Bernina line (St. Moritz – Tirano)

55

Kilometre markings

| Station | m |
|--------------------|---------|
| St. Moritz | 1,774.7 |
| Celerina Staz | 1,716.1 |
| Punt Muragl Staz | 1,736.4 |
| Pontresina | 1,773.7 |
| Surovas | 1,822.1 |
| Morteratsch | 1,896.0 |
| Bernina Suot | 2,046.2 |
| Bernina Diavolezza | 2,082.2 |
| Bernina Lagalb | 2,099.4 |
| Ospizio Bernina | 2,253.2 |
| Alp Grüm | 2,090.8 |
| Cavaglia | 1,692.1 |
| Cadera | 1,383.1 |
| Privilasco | 1,118.6 |
| Poschiavo | 1,014.3 |
| Li Curt | 988.1 |
| Le Prese | 972.9 |
| Miralago | 965.1 |
| Brusio | 780.2 |
| Campascio | 636.6 |
| Campocologno | 553.0 |
| Tirano | 429.3 |



Core zone with railway and cultural landscape

Buffer zone

- Buffer zone in the near area
- Buffer zone in the distant area (backdrop)
- Horizon line

Other contents

Other stretches of the Rhaetian Railway

Sources: Basic map: PK 200'000 swisstopo, Wabern Geo-data: Amt für Raumentwicklung Graubünden Thematic data: Gion Rudolf Caprez Design: Süsskind, SGD, Chur Reproduced by permission of swisstopo (BM062220)

Bernina line (St. Moritz – Tirano, built 1906 – 1910)

The Bernina railway runs from St. Moritz in the Upper Engadin through the Poschiavo valley to Tirano (Italy). Built between 1906 and 1910 it was incorporated into the Rhaetian Railway in 1944 (cf. 2.b.5). Two factors were decisive for its construction: the necessity to provide access for construction and maintenance traffic to the planned hydroelectric stations on the south side of the Bernina Pass (cf. 2.b.7), and the need to provide day trippers with convenient access to the renowned tourist attractions in the high mountain area. Cantonal subsidies were declined. Financing was secured by the same stockholders who were involved in the Kraftwerke Brusio AG (KWB, today Rätia Energie AG).

The construction of a costly, steam-powered mountain railway based on the example of the Albula line was, in the case of the Bernina line, for financial reasons, not taken into consideration. The new technology offered by the electrified, surface railways gave an opportunity for constructing the desired railway link over the Bernina within the limits of the resources available. Electrically powered railcars could manage much greater upgrades and much tighter curves than steam-powered locomotives, permitting a flexible alignment. In this specific case, this led to the option of using the road built over the Bernina Pass around the middle of the 19th century (cf. 2.b.3) as the trackway for the new railway line, thus saving considerable costs in the construction of the track. It was originally intended to run the whole of this section of the line alongside the road, but eventually it proved necessary to construct a special railway corridor for more than 75% of the section; the selection of the route for the railway through Cavaglia, Alp Grüm and the top of the Bernina Pass had to take the needs both of the power stations and of tourism into consideration.

In order to keep the line operating during the winter months, the financial contribution from public funds, which had been turned down at the time the line was constructed, had to be accepted soon after 1914. The year-round usability of the Bernina railway could only be achieved with subsequent, localised improvements and constant snow-clearing work – with the Albula line, the large amount of capital invested made it possible to plan in all the (construction) measures required to permit all-the-year-round operation from the very beginning.

Standards

The standards for curves and upgrades on the Bernina line were set with regard to the need to keep the volume of earth movement as low as possible. Where earth movement was unavoidable a smaller cross-section was used compared to that of the Albula line. In the Albula line, a 2 m deep cutting led to an excavation cross-section area of 24 m^2 ; with the Bernina line a cutting of this size only required an excavation area of 17 m^2 . The standards for dry masonry, mortar masonry and for walled vaults correspond to those of the Albula railway, although because of the lighter weight of the motor units compared to that of steam locomotives it was possible to construct the vault some 5 cm thinner.

- > Track gauge 1,000 mm
- > Curve radius minimum 45 m, normally 60 m
- > Upgrade maximum 70 % (46 % of the length of the section has an upgrade of 50-70 %).
- > Width of formation 3.60 m
- Catenary voltage 750 V= (direct current), from 1923 1,000 V=
- Passing length in the stations originally 90 m, today minimum 150 m



Bernina line > Profile of the stretch (reduced in size). Bosshard E., *Die Berninabahn*, Zurich 1912 ("Schweizerische Bauzeitung", offprint).

- > Railway loading gauge 3.00–3.35 m width
- > Slope angle of embankments 2:3
- Slope angle of cuttings 4:5 (steeper than the Albula railway)
- > Width of cutting at sleeper height 5.95 m, with side walls 4.6 m (Albula railway 6.65 m).
- > Taper of mortar masonry 1:5
- > Taper of dry masonry 1:3

Longitudinal profile, route planning

In terms of the longitudinal profile, the Bernina railway can be divided into a St. Moritz-Morteratsch subsection, which can also be described as the "Engadin excursion railway", the northern ramp between Morteratsch-Ospizio Bernina-Scala with its passage through the mountain pass scenery, and the southern ramp, which is only interrupted by a section on the valley floor between Poschiavo and Miralago. The line may also be subdivided into sections where the line has its own corridor and sections with a corridor beside the mountain pass road and the valley road (railway line positioned alongside the road). With the exception of the unavoidable turning tunnels and short tunnels behind rock spurs the original design did not provide for any tunnelling activity at all. The only long tunnel, in the Charnadüras Gorge, only became necessary as a consequence of a design change which arose during the construction approval phase of the project. The long tunnel sections in the area of the mountain pass came into being when the railway was already in operation; these are the result of tunnel extensions and of connections between a number of tunnels made by means of galleries. The construction of new, largespan bridges was also avoided where possible in the construction of surface railways, either through the shared use of an existing road

bridge or by avoiding discontinuities in the terrain.

The simple alignment needed for operation by electrical motor units meant that extensions and corrections to sections of the line could be made within an acceptable level of expenditure. Corrections to the alignment of the Bernina railway fall into the following categories:

- > changes made shortly before or during construction
- > section relocations for winter operation
- > track relocations for winter operation or to allow for larger curves
- > track relocations to separate road and railway

Organisation of the stations

With the exception of the terminal stations and the railway stations in Poschiavo and Pontresina all the intermediate stations on the Bernina railway were given only very modest facilities. Initially the station buildings between St. Moritz and Poschiavo were just simple timber pavilions. For winter operation the Bernina railway constructed a series of better-quality stone structures both for the station buildings and for other buildings needed to serve operational requirements (cf. 2.a.5). Several times, new passing stations were constructed whilst others were removed or downgraded to halts without passing facilities. The track systems on the intermediate stations consisted simply of a passing track. Where possible, track slopes were reduced in the area of the stations and the stations constructed along a flat alignment. Where necessary the station facilities were extended, for example by the addition of a turntable for the steam-powered snow

blowers, or by dead-end tracks where additional coaches could be positioned at stations used by high numbers of tourists.



Pontresina > The two lines St. Moritz-Pontresina (right) and Samedan-Pontresina (left) stand out clearly on the aerial view. A. Badrutt



Pontresina > The Rhaetian Railway's Bernina Express on an embankment shortly before Pontresina. Foto Geiger

Power supply and rolling stock

The Bernina railway was originally provided with AC current from the Campocologno power station, which belonged to the KWB the current was fed to four transformer substations (Pontresina, Ospizio Bernina, Poschiavo, Campocologno) by means of a high voltage line which ran parallel to the railway but in its own corridor. The high voltage line and the transformer buildings are still in existence, although the number and the technology of the rectifiers continued to be modified over the course of time.

Services on the Bernina railway had always been operated using four-axle motor units; other rolling stock included locomotives for freight traffic and service trips, and special vehicles used for snow clearance.

Short description of the individual sections of the route

The kilometre distances used in the following notes are based on those in use when the line was constructed; kilometre 0.0 is in St. Moritz. Where sections of the line were relocated, what were known as 'error profiles' were added, which provided a local correction for the difference in length.

km o – 12: St. Moritz – Morteratsch

The Bernina railway's station in St. Moritz (km 0.0) had to be integrated into the facilities of the Rhaetian Railway, constructed in 1904. The only site available for the covered platform and for a pedestrian underpass was a short area, skewed to the line of the Rhaetian Railway, which lay between the Hotel Bristol (today Bellaval Hotel) and the place where the bridge over the river Inn was to be sited. Apart from deadend tracks for passenger coaches the Bernina railway did not have any technical facilities in

St. Moritz. After the station the railway line crosses the Inn by means of the Charnadüra viaduct (km 0.2). In the first years after the opening of the line the view of this bridge became one of the well-known picturesque images of the Bernina railway; today the main road passes below it. The line passes behind the Charnadüra Gorge by means of the 689 m long Charnadüra tunnel (km 0.5) which has a downgrade of 30 ‰. A panel on the keystone of the upper portal shows the year of construction, "1908". After the tunnel there are no other large engineering structures on this section of the line; its alignment is able to adapt to the terrain, the line running in its own corridor in continuous curves and counter curves. Today the former Celerina railway station at km 2.0 is only used as a halt. A road constructed by the railway connects the station to the village on the opposite side of the valley. Following the takeover of the Bernina railway by the Rhaetian Railway this station was renamed Celerina Staz to distinguish it from the Rhaetian Railway's Celerina station. The station marks the lowest point on the northern section of the railway line – it is 58 m lower than the railway station in St. Moritz. The station building was constructed as a chalet and dates from 1922. The line continues on, running partly at the foot of the slope and partly along an embankment constructed across the marshy floor of the valley (km 2.3). Travellers on this section of the line have a pleasant view of the San Gian church. The railway then begins to rise at a rate of 20 ‰ and turns southward, into the valley of the Flazbach. A link road runs from the Punt Muragl Staz halt (km 3.5) along a steel bridge over the Flazbach to the valley station of the Muottas Muragl cable car. The section continues to climb towards Pontresina. There are almost no engineering structures along it apart from drainage ditches



Bernina line > From Pontresina to Morteratsch the track runs through forests of Swiss stone pines and larches. A. Badrutt



Bernina line > Morteratsch station and the steel bridge across the Ova da Morteratsch. A. Henkel



Bernina line > The stone arched bridge across the Ova da Bernina is still impressive today. A. Henkel

and some smaller earthworks. The Samedan– Pontresina line approaches from the left; this line belongs to the Rhaetian Railway, and was designed separately.

Pontresina railway station (km 5.8) was important for the Bernina Railway as transit station for the Rhaetian Railway because the stretch from Bever ended here. The station building and tracks 1 - 3 which run in front of it belonged to the Rhaetian Railway. The Bernina Railway, as tenant of the Rhaetian Railway, used tracks 3-7. Originally the covered platform (track 1) was used by the Bernina Railway as well. After electrification of the Rhaetian Railway (alternating current) in 1913 the tracks had to be separated; the underpass and central platform, which are still in use today, were built at the same time. Track 3 can be switched to either of the two different electrical systems of the Rhaetian Railway and the Bernina Railway; the Bernina Railway was been powered by direct current from the outset. Today, Pontresina station is still the technical basis for the northern section of the Bernina line. The technical installations consist of the depot workshops with the original three-track parking shed and the updated rectifier equipment, still sited in the transformer building from 1907. Other station facilities include the three "Cuntschett" staff houses dating from 1911. In deviation from the original plan, which had the Pontresina-Morteratsch section of the railway line follow the line of the mountain pass road, the section in this part of the line was run along the left side of the river up to the Morteratsch Hotel. This change was probably mainly due to the idea of providing tourist access to the imposing Morteratsch glacier; projects to build a tramway from the upper Engadin as far as Morteratsch had existed even before the construction of the railway. The hotel existed before the Bernina

railway was built. When constructed the hotel was very close to the tongue of the glacier; in the decades since then this has receded significantly, due to global warming.

Immediately after Pontresina railway station the line moves out of the side valley, Val Roseg, along a short loop; the stone arch Val Roseg bridge (km 6.3) is located at the apex of the loop. A 500 m long ramp with an upgrade of 70% brings the line up to the level of the fluvial plain of the Ova da Bernina. The site where Surovas railway station is located (km 7.2) was originally occupied by the Sanssouci halt. A passing track and the existing station building were constructed here in 1929; adoption of the present-day name of the station seems to be linked to this. The track system was renewed in 2005. From Surovas to Morteratsch the line follows a polygonal route which involves minimum working of the terrain. The favourable terrain here also allows higher running speeds. In view of the risk of avalanches a concrete observation post with lookout slits was erected at km 9.6. Massive walled and concreted dykes $(km \ 10.5 - 11.8)$ protect sections of the line from the floodwaters of the Flazbach; the closeness of the line to the river here led to the need for a large number of barriers. Shortly before Morteratsch the line runs through an Alpine pasture landscape with stone pines and larches. The St. Moritz-Morteratsch section was intended for year-round use from the time the line was opened. For this reason Morteratsch railway station (km 12.1) was given a passing track and a siding for additional coaches. The length of the station was initially limited by the entry curve, the level crossing and the break in slope before the bridge. Today's facility is the result of an extension and a larger radius curve which swings out on the side towards Surovas.



Bernina line > The views of the Morteratsch glacier from the Montebello open loop are fascinating. P. Donatsch



Bernina line > Even today the train still runs on the track of the old roadway which was widened when the train was built. A. Henkel



Bernina line > The upper bridge over the Bernina stream with stonework abutments, simple girders and hinged columns. T. Keller

km 12–24: Morteratsch – Scala

Above Morteratsch the line negotiates a section of terrain rising 120 m by means of a 1,720 m long ramp with an upgrade of 70 %. With this steep ramp the Bernina railway line shows its spectacular side for the first time. The views of the Morteratsch glacier - which can be enjoyed from both sides of the railway carriages, thanks to the open Montebello loop - have been standard motif choices for tourists and postcard photographers since the line was opened. The bridges over the Ova da Morteratsch (km 12.2) and the Ova da Bernina (km 12.4) are the most noteworthy structures on the north ramp. The former - which has already been replaced twice since it was first constructed - is a steel structure and was much criticised in conservationist circles because of the material selected for its construction; the latter is a stone arch bridge which is still much admired today. Its positioning in front of the Berninabach waterfalls, already known as a beauty spot before the railway was constructed, has created an impressive setting uniting engineering structure, railway and nature harmoniously. Here the line also crosses the pressure line of the Morteratsch power station which was constructed in 1891 (today the pressure line runs underground). The open Montebello loop (km 13.0) uses the terrain in a most skilful manner. The line, rising constantly at 70‰, describes a 180° turn with a curve with a minimum radius of 45 m. Two engineering structures were built here: a retaining wall on the valley side to allow the railway line to swing out and a cut into the mountain to allow it to swing back in. The mountain pass road crosses the railway line at the point of contact between the two structures.

The Montebello battery station (km 13.9), built in 1914, provided the electricity supply for the

railway until 1927. The "tomato house", the name given it today, comes from its later use as a warehouse, primarily for storing canned tomato puree. The steep ramp ends at km 14. Up to Arlas (km 20) the Bernina railway originally ran alongside the mountain pass road - its alignment was an adoption of the original design which had proposed that the Bernina railway would also have an integrated road; this design had been altered in favour of the alignment over the Alp Grüm. Today only the section from km 14 to 15.2 runs alongside the road. At km 14.5 the line passes a military barrier dating from the time of the First World War (concrete tunnel with the text "IV/6 1915", a building at the foot of the slope with a plaque "Albrishütte 1915 IV/6"); higher up the slope there are several bunkers which are part of a barrier dating from the time of the Second World War. The railway and the road switch to the other side of the valley before reaching Bernina Suot railway station (km 15.7), originally known as the "Berninahäuser" railway station. The road, railway line and the station building in this section were all reconstructed in 1993. The open turntable built in 1910 for the steam-powered snow blowers was replaced as early as 1915 by an avalanche-proof shed with a covered turntable. In the section between Bernina Suot and Bernina Lagalb (km 17.9) the train still runs today along the road corridor which was widened when the line was constructed; the road itself was set deeper. Road bridges and tunnels were also widened by 2m for the railway, where construction joints still provide an indication of this measure today; the tunnel at km 16.5 has a keystone which shows the year "1907". The Bernina Diavolezza halt (km 16.8) was constructed in 1956 as a passing station to serve the cableway which was built at that time. The construction of the Bernina Lagalb railway station (km 17.9) is



Bernina line > Crossing the ridge of the Bernina alongside the Lago Bianco (white lake). T. Keller



Bernina line > In the foreground the Lago Bianco, behind it the darker Lago Nero (black lake). T. Keller



Bernina line > The Bernina Railway reaches its highest point - 2,253 m - at the Ospizio Bernina station. A. Henkel

linked to the Lagalb cableway which started operation in 1962. The latter station replaced the passing points of Diavolezza and Alp Bondo. In 1934 the railway corridor between Bernina Lagalb and Arlas was relocated from the right to the left slope with a view to protecting the line from avalanches. Of the original 1.8 km long section which ran alongside the road, signs can still be seen of the road edge on the valley side with shoulders and conduits; at km 18.7 (old) a memorial stands to honour the eight railway employees who lost their lives in an avalanche on the 16th March 1920. The new section on the western slope is safe for use in winter; it is 400 m longer and also has more curves than the old section. The alignment was also built with many changes in slope as the Ova da Bernina had to be crossed twice. Four steel bridges with walled abutments, simple girders and hinged columns give this section a uniform appearance.

The Arlas gallery (km 20) dating from 1909/10 is the oldest avalanche gallery on the Bernina railway.

The steep ramp which began after the Bernina Lagalb railway station, ends shortly after the gallery. A stone building stands on the site of Arlas station, the former coaling and watering station, (km 20.4), which was in use between 1923 and 1957.

From km 20 to km 24 the line crosses the wide, almost level crest of the Bernina pass; here the alignment has to take into account the need for protection against the forces of nature. This is achieved more as a result of experience than through design, explaining why the section is marked by a large number of smaller corrections to the alignment, which remain visible in the Alpine landscape for a long time. The panoramic curve of Val Bügliet (km 21.6), where the line crosses a side valley by means of an embank-

ment with a vaulted tunnel, has long been a popular subject for photographs; the scene with the train in the foreground, Lago Bianco in the centre ground and the Piz Cambrena in the background could not be more spectacular. The section along the lake is particularly popular as a subject for winter photographs; photo reports from the 1910's showing snow clearance operations and the transfer of the passengers to sleighs remind one of the Polar expeditions which were then in the news. The Ospizio Bernina railway station is at km 22.3, and here the railway reaches its highest point, at 2,253 m above sea level. The tower-like station building dates from 1909; it was added to in 1925 by the architect Nicolaus Hartmann the younger, creating the building which exists today (cf. 2.a.5). A 550 m long road links the railway station to the top of the pass. A group of buildings stands at the southern end of the station. The group consists of a transformer station (1910), a covered turntable (1926) and a dwelling house (1912). The next section of the line, along the reservoir, has a maximum downgrade of 30 ‰. At km 23 there was originally a curve with a snow gallery; in 1949 the railway line here was moved from the bank of the lake into the arm of the lake, which it now crosses by means of a steel bridge.

km 24-44: Scala-Poschiavo

At km 24 the crossing of the peak of the Bernina pass, where the line runs more or less horizontally, now turns down into the southern ramp. From Scala to Poschiavo the line had to deal with a change in height of some 1,200 m, which it accomplished at an almost continuous maximum downgrade; here the alignment had to avoid any natural hazards and yet at the same time provide access to popular tourist attractions. Engineering features on the alignment of this section



Bernina line > The spectacular layout of the line at Alp Grüm seen from the helicopter. A. Badrutt



Bernina line > The most striking feature of the Alp Grüm station is the reception building, built by Nicolaus Hartmann the Younger, in 1923. In the background left the Palü glacier. Rhaetian Railway



Bernina line > The much admired panorama of the base turn at Alp Grüm extends from the loop at Stablini, over the Cavaglia plain, the Lago di Poschiavo and the Aprica pass to the Alps at Bergamo. Foto Geiger

include the triple crossing of the steep slope of Alp Grüm, by means of one open loop and a second running in a tunnel, the loops of Scala and Stablini, La Dota and Val Pila, and the five crossings of the slope of Cadera. The type of alignment and the occasionally inadequate protection against storms and avalanches were sometimes seen as evidence that the Bernina railway was originally designed only as a summer railway for tourists. However, statements made by those involved in the construction together with findings made on site lead to different conclusions. According to the resident engineer Eugen Bosshard for example, the loop near Scala was determined by the location of the dam on Lago Bianco; only the s-shaped alignment and the position of the curve at the edge of the terrain made it possible to gain the necessary height without involving large-scale earthmoving works. The picturesque situation with the view to the south is therefore the result, not the cause of the Scala curve. The correction made in 1924 did indeed call for the construction of a high embankment; the cost of constructing such a feature at the time the line was built would have exceeded the financial resources available. An analogy can be drawn here to the pioneering railways in America; these too initially had as low-cost an alignment as possible. The alignments were only improved later on, using income from the operations and bearing in mind the lessons gained from practical experience. The traverses of the slopes below Sassal Masone and Alp Grüm also initially ran in the open – with the clear knowledge of the risk of avalanches in these locations - and were only protected by galleries later on. The alignment of the Bernina railway was not made in ignorance of the inherent dangers, but rather based on the acceptance of a calculated risk. In designing the alignment between Stablini and Cacaglia use

was made of the indentation of Val Pila to allow the section to be lengthened without having to cross the avalanche tracks in the upper part. The Scala gallery (km 24.4) is made from steel sections with concrete sidewalls and corrugated iron roofing and dates from the year 1911; it protects the railway line from storms and snowdrifts. At the subsection between km 24.7 and km 25.2 the old trackway of the loop which swings out to the left is still clearly visible, and is still ballasted. The corrected alignment runs along an embankment and was constructed in 1924. The old line was connected to the new by means of points, and so could be used in summer as a passing track; points and track were removed in 1941. The still existing stone built guard's hut at this point is associated with the former passing lines. The outermost edge of the old trackway offered a spectacular view - although this had to be "purchased" at the expense of risking the trains by exposing them to sharp gusts of wind and snowdrifts.

The large southern ramp begins at the bridge over the Acqua da Pila (km 25.3), where it has a 70% downgrade. The adjoining 631 m long Galleria Lunga comprises the Scala and Pozzo del Drago tunnels, the Sassal Masone gallery which links them, and the galleries built in advance of the two tunnel portals. Beyond the gallery the railway line crosses over an embankment to the left of the Pru dal Vent valley (km 26.1); from here travellers have their first view of the Palü glacier. Also to be seen from this section are the southern dam on Lago Bianco and the KWB (today Rätia Energie AG) pressure line. The first of the three traverses of the Alp Grüm slope commences at km 26.7. In terms of alignment it calls to mind the serpentine curves of a mountain road rather than the typical alignment of a railway line. All attempts to stabilise this



Bernina line > The layout of the line as it climbs Alp Grüm is more reminiscent of the zigzags of a pass road than a railway track. T. Keller



Bernina line > Rhaetian Railway train at Stablini. Foto Geiger

slope by means of afforestation failed, so that all three of the traverses are now protected by galleries.

The Alp Grüm railway station (km 27) was constructed at a (relatively) safe location. On the mountain side, the station is bordered by cuttings into the rock and by revetment walls. Originally there was only a passing track about the length occupied by the upper half of the present station, and a timber station cabin. The large volumes of passenger traffic and the need to staff the railway station in winter led to track system and buildings being extended a number of times. The station building by Nicolaus Hartmann dating from 1923 is quite striking (cf. 2.a.5).

The station is followed by a turning curve constructed on an earth embankment (km 27.2). The much admired panorama offered to the traveller at this point extends from the loop near Stablini, over the Cavaglia plateau, the Lago di Poschiavo and the Aprica pass and on as far as the Bergamo Alps.

The 839 m long Palü gallery (km 27.6 – 28.5) consists of a 254 m long turning tunnel and the avalanche galleries which adjoin the two tunnel portals; the avalanche galleries were constructed in stages between 1911 and 1949. At km 27.8 a memorial stands in memory of an accident caused by an avalanche in 1937; at that time this point on the line was still without any protection. The transverse profile of the railway line in this section along the steep slope consists of a dry jointed, covered retaining wall, the track with lined drainage ditches on the mountain side, and the mortared revetment wall. The latter was heightened and backfilled when the galleries were constructed.

The Palü power station situated below the railway line was built in 1927 (cf. 2.b.7) and can be clearly seen from the train; a materials platform

along the track (km 28.5) and traces of a cable landing, date from the time the power station was constructed. In the 334 m long Stablini tunnel (km 28.7) the rail runs behind an exposed rock wall; following the tunnel the line describes an open curve around a promontory. Km 29.2 is a popular point from which to take photographs of frontal views of the train with the Palü glacier in the background. The Stablini passing station (km 29.4) was reconstructed in 2001; there was certainly a passing track here between 1913 and 1960. The construction of a railway station on this natural terrace had been planned from the very beginning; for this reason the gradient here was reduced to 20 ‰ over a length of 186 m. Stablini railway station and the adjoining section of line are protected against avalanches by slope stabilisation measures built between 1913 and 1915; these take the form of dry stone walls and afforestation. The terrain between Stablini and Cavaglia falls steeply by about 250 m. The forced alignment of the railway line made use of the projecting ridge of La Dota and the Val Pila side valley. Thanks to skilful use of the lie of the land only one of the turning curves required on this section had to be run through a tunnel. This Val da Pila turning tunnel (km 29.9) dates from the time when the line was constructed, as probably does the footpath that links the two tunnel portals. Galleries were constructed in advance of the portals in 1913 and 1941. The railway line then runs along a slope and curves round the hill of La Dota. Timber traction poles dating from the 1940's still stood here until quite recently. The dry walled protective piers indicate the original position of the masts. The Val da Pila turning viaduct (km 31.8) lies on a 50 m radius curve. In 2005 it had to be renovated, since the left abutment was threatening to crush the vault as the result of slope movements. The construction of



Bernina line > View of the high altitude plain at Cavaglia. P. Donatsch



Bernina line > The train passes through the Cadera Maiensäss countryside between Cavaglia and the valley plain of Poschiavo. A. Henkel



Bernina line > The two original bridges over the Cavagliasco river had to be replaced by steel bridges due to terrain movements. A. Badrutt

a trackway slab means that following the renovation work there is no longer any thrust against the vault. The loop into Val Pila belongs to the category of "track extension by swinging out into side valleys"; this method was used to gain height in the early days of mountain railway construction, as for example with the Pennsylvania, Semmering and Brenner railways.

On entering the Cavaglia plateau a drainage trench running from the Acqua da Pila passes under the railway line and then continues using the line's own drainage ditches, finally connecting to the field irrigation system. Four spillways in lined trenches lead back to the railway line's drainage ditches and are carried through under the track. At km 32.9 the crown of the railway's revetment wall has a concave shape in order to carry a watercourse. In Cavaglia the sophisticated field irrigation system must have been in full use around 1910, since the design of the railway line had to take it into consideration. At km 32.8 two milk cellars with dry stone walling have been built into the railway embankment. In Cavaglia (km 33.1) the almost continuous upgrade of 70% which the line has been rising at since km 25 is briefly interrupted. Originally only a passing track existed here. In 1911, when for a short period a sleigh service operated between Cavaglia and Alp Grüm during the 6 winter months of the year, the station – as the terminal station of the southern part of the network - was given a dead-end track. A turntable with a watering station was added to this in 1912/13, and the foundations of these facilities can still be seen today. A private hotel was constructed on the railway station in 1912; in 1925 it was acquired by the Bernina railway, which added a station office and a waiting room. At the northern end of the station stands the building containing the buffer battery; the battery was in use between 1910 and

1931 and was intended to improve the power supply in the middle of the ascent from Poschiavo to Ospizio.

Traces of the one meter gauge connecting track built in 1927 between Cavaglia station and the hydroelectric command station of the same name are still visible in the terrain. Cavaglia railway station offers views of the outer curves of Stablini and Alp Grüm.

Between Cavaglia and the throat of the valley at Puntalto, the railway line follows the left side of the valley. Rockfall boulders have been underpinned here by dry walls. The River Cavagliasc runs parallel to the railway; the river disappears into a water catchment belonging to the KWB (today Rätia Energie AG). The railway crosses the deep gorge over a stone arch bridge which lies on a curve, although little of the bridge or of the nearby glacier moulins can be seen from the train. Of the 10 km section between Cavaglia and Poschiavo, following the "passage obligé" of Puntalto it was actually only possible to select the turning points of the alignments freely. The southern turning point near Campello (today, Campel) west of Poschiavo still lay within the concession project. In this variant the construction of a simple, long loop would have been sufficient, although Val Varuna would have had to be crossed twice. In order to avoid this double traverse a design was developed with a double loop development in the Cadera area, with loops on the north slope of Val Varuna; in order to obtain the length required, a turning loop had to be swung out into the Cavaglia Gorge, and this called for the construction of additional engineering structures.

After Puntalto the railway runs along the slope on dry jointed stone pitch slopes with concrete extensions; there are drainage ditches, in part



Bernina line > The operational and technical centre for the south ramp is located in Poschiavo. T. Keller



Bernina line > An imposing view of the landscape as far as the Bernina Pass from Miralago station at the outlet of the Lago di Poschiavo. Foto Geiger made with placed mortared slabs, in part with small stone paving on the mountain side; the side walls in the rock cuttings are well preserved. The railway line uses curves and counter curves to adapt to the lie of the terrain. The Upper Cadera viaduct (km 35.6) is the first of a total of five bridges over Val da Cadera. A passageway with a simple beam (km 35.7) and simple walled abutments runs over a former timber chute. At km 35.8 an outer curve offers a view of the valley floor and of the Lago di Poschiavo. The Val Varuna 1 tunnel (km 35.9) is the turning point of the upper loop. The upper and lower portals are connected by a footpath, which today is overgrown. The lower portal is carefully jointed, abutment and arch stones consist of bossed ashlers with beaten edges. The keystone bears the inscription "1908". The line then leaves the forest to enter the Maiensäss landscape of Cadera; much photographed during the initial years it gradually lost much of its attraction after the line entered continuous operation as all attention was now drawn to the spectacular scenery of the high mountains.

The next loop is in open alignment in the rockfall area of Foppi da Cadera (km 37.2). The Cadera passing station at km 38.2 was constructed to subdivide the long section between Cavaglia and Poschiavo. The timber station building has remained unchanged since it was first constructed; the passing track was recently extended as far as km 37.9. A tower-like rectifier station dating from 1931 stands on the side towards the mountain.

The Val Varuna tunnel 2 (km 38.8) contains the turning curve of the lower loop of Cadera. The view from the lower portal in the flank of Val Varuna out into the valley is a popular motif for postcards; it was used in an advertising poster for the Rhaetian Railway. At km 36.6,

38.7 and 39.1 the railway crosses the surfaced bridleway to Cavaglia, which was still much in use at the time the railway was constructed. The turning curve in the Cavagliasco gorge (km 40.2) had to be constructed in difficult terrain. Earth movements since then have caused the destruction of one tunnel and two bridges. At km 40.4 there is a loading ramp for offloading material onto a runway to the delivery line to the Robbia power station, built in 1910, which also supplied power to the Bernina railway. At km 41.1 the railway line leaves the difficult terrain of the gorge and enters a stretch of common land where it crosses an intensively cultivated lynchet field system. The dry bed of Val da Cadera is crossed for a last time by a steel girder bridge (km 41.4). The Privilasco halt (km 42) was constructed as recently as 1954. For this reason it lies along the uninterrupted slope of 70‰. It is linked to the road by a 20m long footpath. After Privilasco and as far as Poschiavo the alignment of the railway runs at ground level in the taper of Val Varuna.

Poschiavo (km 43.6) is where the operation and engineering centre for the southern ramp is located. The station facilities lie at the foot of the western slope, parallel to the river and to the valley road, outside the centre of the village. An avenue branching off at right angles connects the railway station with the settlement. The present station building dates from 1962. Opposite it, on the other side of the tracks, stands the building with workshops and sheds, for the most part dating back to 1908. The transformer unit is located 100 m to the north of the station.

Poschiavo, the main village in the valley, is the most important focal point for cultural and social interactions between the Bernina railway and the region it provides access to.



Bernina line > The Brusio circular Viaduct is the "trademark" of the Bernina Railway. P. Donatsch



Bernina line > The Brusio circular Viaduct describes a quarter circle and has nine openings each with a diameter of 10 m in a curve of 70 m radius with a gradient of 70%. P. Donatsch

km 42 – 58: Poschiavo – Campocologno

Between Poschiavo and S. Antonio followed the constant succession of curves, straights and changes in slope typical of a simply aligned surface railway. The bottleneck by the S. Antonio church (km 45) was eased somewhat later, the tramway character was however preserved. From S. Antonio to Le Prese the railway – with few exceptions – once again runs alongside the road. Until 1975 the Le Prese halt (km 48) was a station with a passing track. Originally the railway services halted directly in front of the entrance to the hotel.

The main road along the Lago di Poschiavo was quite recently relocated to the slope; the old trackway was preserved and is used today as a pedestrian and cycle route. Thus the structure of a surface railway with a gravelled trackway can be experienced for quite a long stretch. This stretch along the Lago di Poschiavo is not spectacular, in contrast to the stretch near the top of the pass, but it is picturesque. Along the rocky bank of the lake the railway line runs on a trackway cut into the rock, the projecting trackway is supported on walled columns. A bottleneck is guarded by a decommissioned military facility (km 49.6).

Until 1938 the Miralago railway station (km 50.8) bore the name Meschino. The facilities for damming the lake and the water catchments belonging to Rätia Energie AG are located here. The railway runs along a right-hand curve and between a group of houses, after which a longer ramp begins. The railway overcomes an almost continuous 70 ‰ downgrade from the outflow of Lago di Poschiavo down to the valley floor of the Veltlin. In this section it is closely integrated with the use of the surrounding arable land, either by means of protective structures against rockfalls which also serve to protect the road and the farming area, or by integration in irrigation systems or agricultural terraces.

The road and the railway cross the Poschiavino river separately. The road describes a tight reverse curve towards the bridge which is set at right-angles to the river. The railway line also follows a reverse curve - although not so tight but crosses the river at a skew angle by means of a steel truss bridge (km 51.1). Between km 51.2 and km 51.4 a well-preserved section of the railway line runs alongside the road. The following slope traverse is greatly at risk of rockfalls, and has dry jointed shelter walls which have been built to a very high quality of construction. The large pitch slope at km 52.1 reminds one of similar engineering structures on the Brenner and the Gotthard lines. The Brusio aqueduct is integrated into the structure. Above Brusio it was necessary to route the alignment through the cultivated land: the open double loop constructed here (km 53.4) is a masterpiece in terms of adaptation of the railway line to the terrain. The first chestnut trees are now visible, within the open turn. In 2001, Brusio railway station (km 53.9) was given an extension on the valley side; the original length of the station corresponded to that of the flatter track section. The station building dates from 1976.

Shortly after the line opened it was found necessary to construct rockfall barriers in the section after Brusio (km 54.2 and 54.4). They date from 1913 and consist of mortar masonry with a top fixture made of old rails. The worn-out main rails of which the posts are made bear the rolling mill codes "HB&HV 1875" and "GHHUETTE 1875 VII".

Below Brusio another forced alignment was needed in order to bring the railway line back to the valley floor. To realise this an open spiral was constructed consisting of a rockfill embankment,



Bernina line > Alignment along the orchards below Campascio. A. Badrutt

arch viaduct, earth embankment, and a cutting. The Brusio circular viaduct (km 54.7) describes a quarter circle and has nine 10 m openings along a curve with a 70 m radius and a downgrade of 70‰. The lower track level of the spiral runs under the fourth opening of the viaduct. The Brusio circular viaduct, together with the spectacular mountain landscape, has become the acknowledged symbol of the Bernina railway. The reasons for this are perhaps its impressive size and clearly recognisable function, its integration into a special cultural landscape and the aesthetics of the standard components which are used appropriately and in just the right place.

The line continues between two rockfall areas through a well-tended terraced landscape (km 55.8). The line below the Campascio halt (km 56.2) which has a passenger shelter dating from 1960, runs through orchards. The change of valley side shortly before Campocologno is made using the road bridge which was widened to carry the line. During the construction of the line, Campocologno (km 57.6) was upgraded from a simple halt to a border station with its own station forecourt. This was also the point where connection was made to the power supply from the nearby KWB power station. The present station and customs building is a new structure, built in 1947. The - largely original - length of the track system, with its three through tracks and sidings, is limited by the changes in slope. Room for the station was created by cutting back the slope, which is stabilised by a revetment wall. The building at the southern end of the station originally housed a transformer; in the 1960s it was made over to take animals waiting for export and used for this purpose for 20 years.

After the station the railway line runs over a steel bridge (km 57.8) which crosses Rätia Energie AG's renovated penstock. At km 58.1 the train reaches the Italian border. Today only a short, horizontal section gives an indication of the halt for the border control which once stood here.

km 58-61: Campocologno-Tirano

After crossing the border, the train climbs a gradient of 70 ‰ along the steep right hand flank of the valley, adapting to the lie of the terrain in a series of loops. The revetment walls, drainage ditches and walls designed to protect against rockfall are identical to the comparable structures on the Swiss part of the line. The former Piattamala transformer works, owned by the Brusio AG power station but now in disuse, can be seen from the train on the left flank of the valley.

At km 59, in the immediate vicinity of a striking wayside shrine, the railway reaches almost the same altitude as the Viale Italia, the Italian arterial road; from this point railway and road run parallel separated only by a low revetment wall. At La Rasica (km 59.2) they cross the Poschiavino river on separate ridges. Between La Rasica and Madonna di Tirano the road straightens and is also used by the train.

Surrounded closely by buildings, the track runs as far as the square in front of the Madonna di Tirano pilgrimage church, which it crosses in a sweeping curve (km 59.8). The train originally ran along the road from here to Tirano station; the current separate trackway was built in 1938.

The end, or beginning, of the Bernina line is reached at km 60.7 in Tirano station. The tracks run parallel to the Ferrovia Alta Valtellina Sondrio-Tirano, opened in 1902 and now integrated in the Italian state railway (FS). The track installation on the station square was originally open to the skies. Since 1927 it has been covered over by a structure that is also used for border controls. The track system in Tirano is currently being renewed.