



Figure 15. Waihopai hill soils are on the end of a spur (foreground) and pass into Vernon soils with few stones, a short distance further along the track, illustrating the extreme variability of the soils over short distances in this terrain. There is some shallow gully erosion in the concave valley head surface in the distance.



Figure 16. A typical landscape for Waihopai steepland soils. Old slip scars cover much of the steep distant slope; scattered boulders can be seen on the foreground ridge. Waihopai hill soils are on the distant ridge top and Wither/Vernon hill soils on the easier sloping foreground gully head surface. Many of the valley sides are straight-sided suggesting that in geological terms, downcutting is active.





Figure 17. Waihopai steepland soils, with shallow slip erosion and some gully erosion on the lower slopes, and patches of Vernon soils on the upper far slopes.



Figure 18. Hummocky ground at the head of the valley is unusual and may be the site of some former mass movement. The deep gullying suggests that some softer sediments are present.





Figure 19. Waihopai steepland soils on a steep gully side with sheet and slip erosion.



Figure 20. Gully erosion on steep lower slopes with Waihopai and Vernon soils



Figure 21. Old but active deep gully erosion on steep lower slopes with Waihopai steepland soils and tunnel gully erosion on the upper slopes with Wither and Vernon soils. The arresting of gully erosion through pine tree planting may have been more successful had it been extended to the slopes above to restrict water run.

#### 7.4. Wither Soils

Wither soils are the best known soils of the Wither Hills/Redwood Pass area because of the spectacular soil erosion that has occurred and which is visible on many surfaces (Fig. 22). They occur over about 15% of the area mapped. Their general properties (Figs. 23 & 24) include a greyish brown to dark brown topsoil overlying a subsoil which at first is yellowish brown to brown, passing into deeper subsoil that is heavier textured and yellowish brown to brown and with reddish mottles. This overlies a very hard fragic (Bx) horizon, or hard pan that passes abruptly into firm and less prominently structured clay loam. This in turn merges into deeper, somewhat massive silt loam that has variable amounts of stones and which exhibit prominent vertical rill erosion morphology (Figs 24 & 25) similar to that of larger scale penitent weathering. Commonly seen in the upper horizons of the soil are accumulations of light coloured silty textured material (known as siltans), which form as a residue after finer particles have been washed down deeper into the soil. Also present on freshly fractured faces in dry soil are precipitations of salts and at times calcium carbonate (Fig. 26). The hard pan was observed in many places to have a fine vesicular structure and also to have an irregular down-slope dipping layered or semi stratified appearance, rather than a continuous massive form (Figs. 27 & 28).

The sequence of the horizons in Wither soils is more or less the same everywhere, but there is much variation in the thickness and the properties of the individual horizons as well as the overall depth to underlying conglomerate, which in some instances exceeds 4 metres (Fig. 25).

Wither soils, in the upper layers, are formed from loess, a dominantly silt to fine sand textured material blown from aggrading glacial outwash sediments on the Wairau plains during late Last Glaciation times. The lower horizons seen in exposures are a mixture of loess with a few or many stones (Figs. 29 & 30), these having originated from exposures of Marlborough Conglomerate higher up the slopes and deposited together with the loess during the Late Last Glaciation cold climate times. The Marlborough Conglomerate underlies these gravelly loessial beds at a variable depth. Some stones of various sizes may also be present within the upper loess material as well as in the pan (Fig. 29). These have also come from up-slope exposures (ridges) of the Marlborough Conglomerate and are considered to have been transported down-slope by solifluction (small scale slides when thawing of



frozen material takes place) at the time of the loess deposition. Some small clasts in the loess however appear to be wind blown.

Wither soils are less widely distributed than shown in the earlier soil surveys (Gibbs & Beggs 1953, Soil Bureau Staff 1968). In the study by Laffan (1973), Wither soils occupied about 35% of the catchment while in the present survey they are mapped over 15% of the area. The distribution pattern, however is extremely patchy with Wither soils commonly occurring on one side of a gully and Waihopai soils on the other side (Fig. 3). Overall however, Wither soils are more common on lower elevation hilly surfaces and are less extensive on steeper surfaces further from the Wairau Plains. Exposure to wind and distance from the source of the loess may have been a dominant factor in the pattern of loess deposition and hence the distribution of Wither soils.

## 7.5. Erosion and Instability in Wither Soils

The instability of Wither soils and the extensive and dramatic erosion dating from the late 1800's, as well as the mechanisms involved in the erosion process are well known. Gibbs (1945) attributed the cause of the erosion, described as tunnel gully erosion, to a loss of vegetative cover by burning with infiltration by water into subsoil fissures, aided by burrows from a rabbit infestation. The accelerated run-off waters that infiltrated cracks into the deep subsoil scoured tunnels that caused collapse of the surface horizons. The subsurface cracks and fissures were considered to have formed through shrinkage from excessive wetting and drying resulting from a depleted vegetation cover. Once formed, the collapsed tunnels widened with the concentrated waters allowing the formation of open gullies. A fundamental cause however is the existence of easily dispersible materials within the soils (Knodel 1991).

In the investigation of the mechanisms for tunnel gully erosion in Wither soils by Laffan (1973) and Laffan and Cutler (1977) a different explanation for the process of initiation of the gullies to that given by Gibbs (1945) was given. Laffan (1973) measured the soluble salt concentrations, exchangeable sodium percentages, dispersion of soil aggregates and slaking in horizons of soils from differing landscape positions. Laffan (1973) showed that horizons with high dispersion and slaking indexes were mostly the B or C<sub>x</sub> horizons, which also had higher clay percentages and higher exchangeable sodium percentages, while horizons with greater organic C percentages had lower dispersion indexes. The highest dispersion and slaking indexes however were measured in deeper horizons below 1m. Laffan (1973) and Laffan and Cutler (1977) considered that tunnels were initiated, primarily in the dispersible lower B horizon with tunnel deepening and collapse of surrounding material ultimately leading to the formation of the existing extensive gully system.

In the present survey, examples of the erosion process described by both Gibbs (1945) and Laffan (1973) were observed (Figs. 31-33) but the most common cause of collapse appears to be from piping formed at depth rather than at shallow depths in the B horizons of the soils. Erosion is still actively occurring and subsurface water flows, always carrying suspended sediment, were observed on many occasions. Under-runners with collapsed roofs are still forming (Figure 34) and piping that is actively providing a conduit for eroding subsurface materials is not uncommon (Figs. 31-34). Gullying commonly occurs to depths of between two to three metres and sometimes to four metres. This deep gullying is facilitated by the disaggregation and dispersion of the silty-gravelly materials that lie above the conglomerate and below the hard pan. Undercutting and collapse along the sides of the gullies follow the loss of material from the lower layers and ultimately leads to gully widening (Fig. 35) while headward erosion of some gullies to within a few metres of the ridge top is also continuing in places (Fig. 36). Stones within the loess often show *in situ* fracturing (Fig. 37) and this weathering is possibly a result of soil salt concentrations, which may have been much higher during the colder and drier glacial periods.

Some of the materials that are removed by erosion are deposited as sediments on fans on the lower slopes of gullies. Gravelly deposits form where water is concentrated and velocities are highest and deeper silty textured deposits form where flows are dispersed (Figs. 38-40).



Figure 22. Extensive tunnel gully erosion in Wither hill soils, occurring most commonly on the eastern side and north facing slopes of the ridge and gully system.



Figure 23. Typical profile



Figure 24. Wither hill soil showing typical weathering characteristics. The hard fragic horizon is below the auger handle with the fretted dispersible clay loam horizon below. Underneath is the gravelly loess with strongly developed vertical rills.