GEOLOGY

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Geological setting

Inangahua lies at the northern end of the 60-mile-long Grey-Inangahua Depression, a complex structural feature between predominantly-granite ranges to the east and west. It contains up to 10,000 ft of Tertiary and conformably overlying Lower Quaternary sediments, but, because of a general southerly plunge, the preserved thickness diminishes rapidly northwards from 10 miles south of Inangahua. In summary, the sediments consist of basal coal measures, siltstone grading up to limestone, followed by muddy sandstone, further coal measures and thick gravel. The Late Quaternary succession of glacials and interglacials has left a suite of gravel terraces in the valleys.

Deformation of the region during the Late Tertiary and Quaternary Kaikoura Orogeny was widespread, even Lower Quaternary deposits now being locally tilted vertically. Evidence of folding is clear in the deposits in the depression, the margins of which are locally faulted. Continued movement in the Late Quaternary is demonstrated by deformation of terraces on the western side of the depression. Movement was not, however, confined to the depression. The granite range to the east has been deformed by Late Quaternary warping and faulting amounting to 400 ft, as shown by a high gravel terrace of the Buller River through its upper gorge northeast of Inangahua (Suggate, 1965). Smallscale faulting and tilting of terraces the nearest being 15 miles south-west of Inangahua, was ascribed by Suggate (1957) to folding of the underlying Tertiary rocks associated with the rise of the Paparoa Range to the west.

Earth deformation accompanying the Inangahua earthquake

Faulting took place at two localities (Fig. 1), near Inangahua Junction railway station and about three miles north of Rotokohu. In both places movement comprised horizontal, vertical and thrusting components.

The Inangahua trace marks the rejuvenation of a fault that had already displaced a terrace surface at least twice since that surface was formed, probably in late Otira (Last) Glacial time, about 20,000 years ago It is thought to lie on the southerly extension of the major Glasgow Fault, which 2 miles to the north of this trace at the Buller River separates Upper Tertiary sediments from Lower Tertiary and basement rocks. The trace was most clearly seen at the railway line (Fig. 2) and diminished to a small roll in the turf about $\frac{1}{4}$ mile to the south. Northwards it was followed for $\frac{1}{2}$ mile, diminishing in prominence and splaying into two smaller traces which trend between north and 020°. The maximum displacement is about 16 inches both horizontally in a sinistral sense and vertically. Overthrusting amounts to at lease several inches.

The Rotokohu traces consist of several parallel but staggered traces upthrown to the south, trending at 060° - 080° and extending over a length of 1 mile. Individual traces show displacements of the terrace surfaces up to about 3 ft both vertically and horizontally. Over a zone about

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50 ft wide parallel to and including the fault, however, the horizontal displacement amounts to about 6 ft. Shortening across the fault is about 2 ft. The traces are marked by "mole track" features consisting of compressional rolls and tensional cracks that in detail deflect the line of the scarp (Fig. 3). The traces are parallel to the strike of the underlying Upper Tertiary sediments as judged by observations at the Inangahua river bank to the west and, rather further away, in Coal Creek to the east. The traces are at a sharp anticlinal bend and are thought to be bedding faults resulting from failures on bedding planes between different lithologies. They indicate continued folding within the Grey-Inangahua Depression.

The horizontal/vertical (H/V) displacement ratios at the two localities and the angular relationship between traces (Lensen, 1958) indicate a probable regional net shortening in a 127° - 307° direction.

A quadrilateral across the Inangahua trace surveyed towards the end of May and the beginning of August has shown continued slight uplift of the upthrown side and sinistral rotation of the downthrown side.

The total deformation of elastic and permanent nature (Lensen, 1968) since previous surveys between 60 and 10 years ago will be determined when the results of reoccupying old cadastral survey marks in both the Inangahua Junction and Totokohu areas are computed.

Damage in relation to surface deformation

In Inangahua Junction, houses built close to and on the upthrown side of the fault scarp suffered only minor damage, while houses further away suffered considerable damage.

The fault scarp displaces Otira (Last) Glacial outwash gravels which prior to the first instance of faulting consisted of identical material with the same depth to water table on the two sides of the future fault line. Faulting uplifted the eastern side resulting in ponding on the western side Continued fault movement kept the western side under continuous swampy environment resulting in poor foundation conditions, while on the eastern side the depth of water table was continuously lowered due to uplift. It is not unexpected therefore that the house opposite the intersection of the main road and the road to the station, and to a lesser extent the houses at the station itself, were more badly damaged than those on the east of the scarp.

Thus ground conditions for buildings are more important than the proximity to a fault provided the buildings are not located within the fault zone itself.

Comparably, houses on the lower terraces with shallower water table at Inangahua Camp were more damaged than those on higher terraces.

Landslides

Many types of landslide, mainly within 10 miles of Inangahua Junction, scar the landscape. The shear stresses set up in the rocks by the earthquake engendered forces exceeded the shear resistance along the joints and other planes of weakness. The mechanisms that produced these higher-than-normal stresses are not fully understood, but include both the high lateral and in places upward accelerations imparted to the rock and soil particles by the earthquake, and by the high dynamic ground water loading in soils and in the joints of rocks.

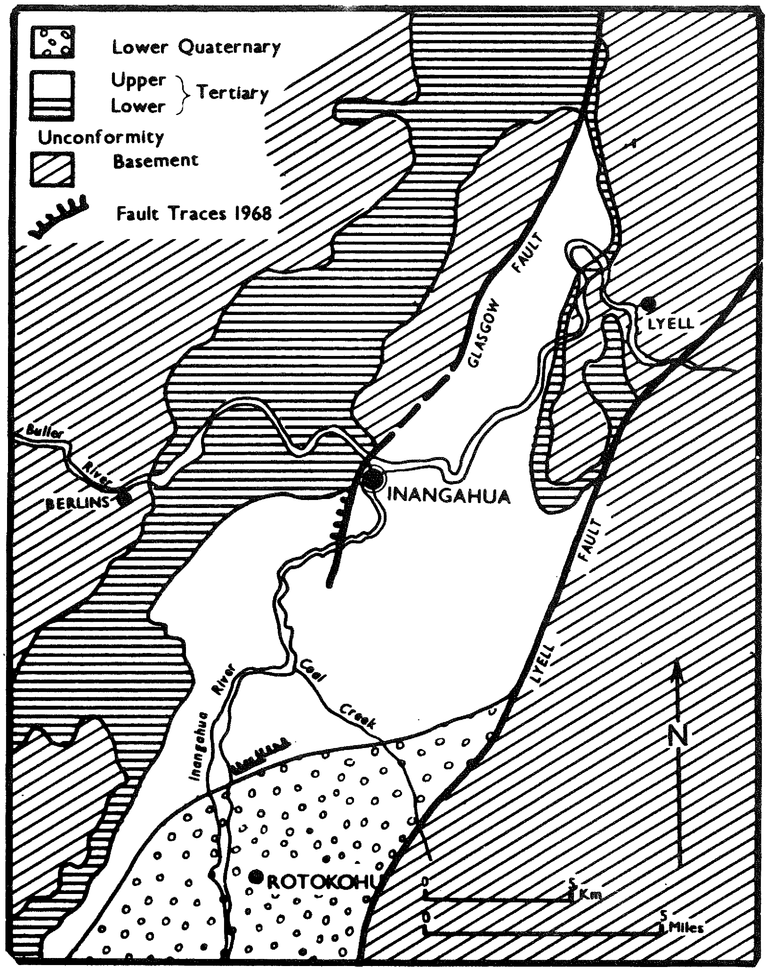

Fig. 1. Map showing the distribution of lower Quaternary, Tertiary and Basement rocks, the major geological faults and the Inangahua and Rotokohu surface traces.

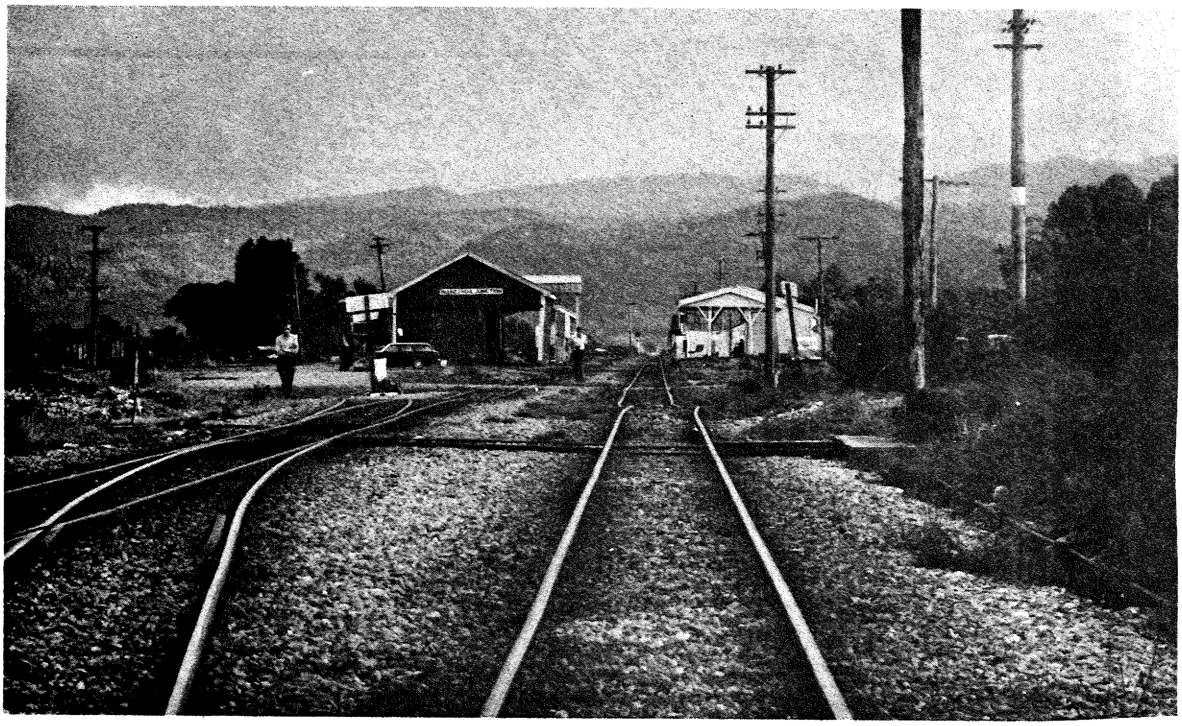

Fig. 2. Looking southward along the railway line and taken from the upthrown **side of the** Inangahua trace, and showing horizontal sinistral offset of **railway** line. photo NZGS L. Homer

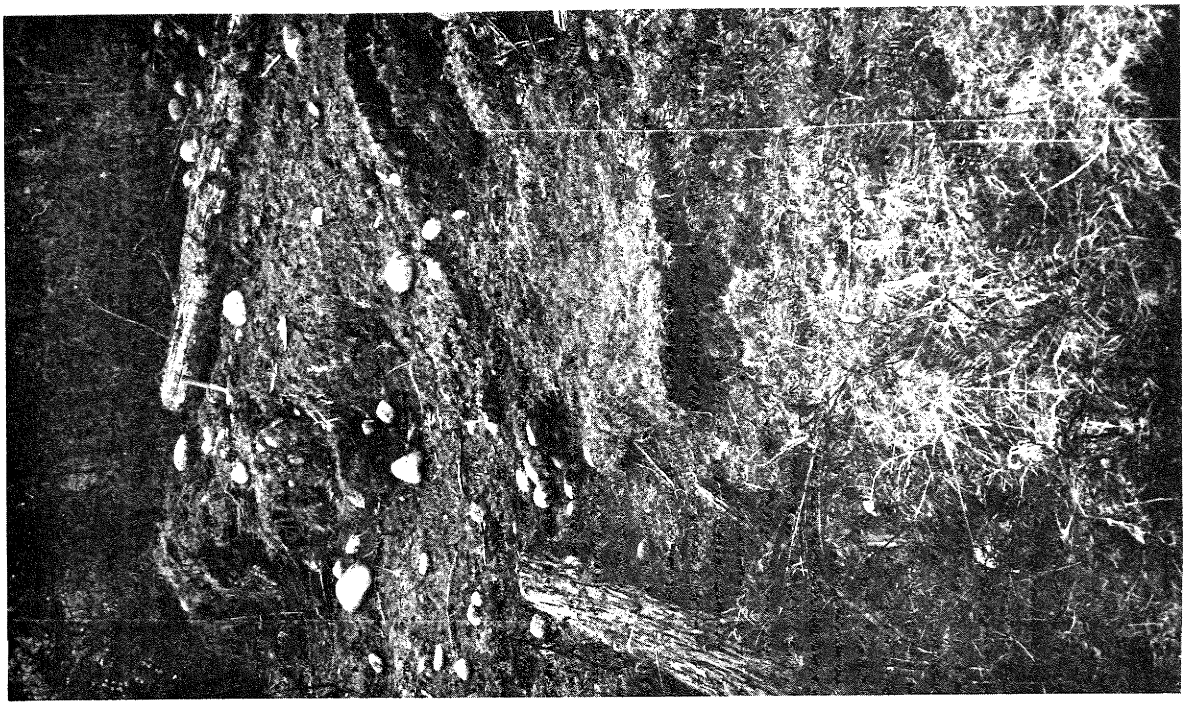

Fig. 3. "Moletrack" features of compression rolls and tension cracks on Rotokohu traces. photo NZGS L. Homer

Fig. 4. Avalanche in granite consisting of granite blocks and near surface weathered material that temporarily blocked the Buller River. L. Homer

The landslides observed can be placed in many different classes according to the type of failure, and each of these various classes can be correlated closely with rock and soil types.

Despite the consequent irregularities of distribution, most of the landslides affecting the natural landscape were within a 10 mile radius of Inangahua, with rather fewer to the north and north-west within that radius. Much particular damage by landslides was clearly related to road cuttings and fill. Rockfalls predominated at the near-vertical limestone bluffs west of Inangahua. Slides on bedding occurred in Upper Tertiary sediments, a remarkable example being at Oweka where a mass of some 3 million cu. yds moved bodily on a plane dipping less than $3\frac{1}{2}^{\circ}$. Slides on joint surfaces were common in the granite, but much of the more spectacular slipping, including the slide that temporarily blocked the Buller River (Fig. 4), was of blocky and weathered near-surface material on very steep slopes. Prominent near Inangahua Junction were earth-flows of weathered Upper Tertiary muddy sandstone-water-saturated weathered material that in sliding disrupted a small amount of underlying unweathered sediments. A few rotational slides occurred in Upper Tertiary sediments; upstream of the Buller railway bridge rotation raised the river bottom above river level at the toe of one slide. Debris slides in surface material at weak crush zones in granite were numerous, for example along the Glasgow Fault north-west of Lyell.

Summary

Tectonic movement associated with the Inangahua Earthquake renewed faulting on an important fault at Inangahua Junction, thus reinforcing the relation of faulting to major earthquakes, already well established in New Zealand. In addition, at Rotokohu folding was renewed in the strongly folded Upper Tertiary rocks, resulting in a localized set of bedding faults. Surveys to establish the ground deformation, including some adjustments since the main movement, have been undertaken. Damage from landslides was closely related to lithology and jointing.

References

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