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Field Trip 9

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Faults, Landslides, Precarious Rocks and Dam

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Introduction

This one day fieldtrip will expose you to one of New Zealand's most intensively-studied areas in the context of Quaternary earth science. Over the last four decades the Cromwell Gorge area and surrounds have seen major studies of large landslides, active faults, and seismic hazards. The studies have been motivated by the need to understand the potential impacts of geologic hazards to hydropower developments, and secondary impacts to the downstream areas. The fieldtrip will include: the landslides of the antecedent Cromwell Gorge, the foci of extensive studies in the late 1980s to early 1990s; the Dunstan Fault, the most active and well-studied fault in central Otago; a tour of the Clyde Dam, the largest concrete dam in New Zealand, and; the precariously-balanced rocks of nearby Cairnmuir Flat, which have been used to quantify local seismic hazard estimates. The journey and key features (Fig. 1) are described in the following commentary.

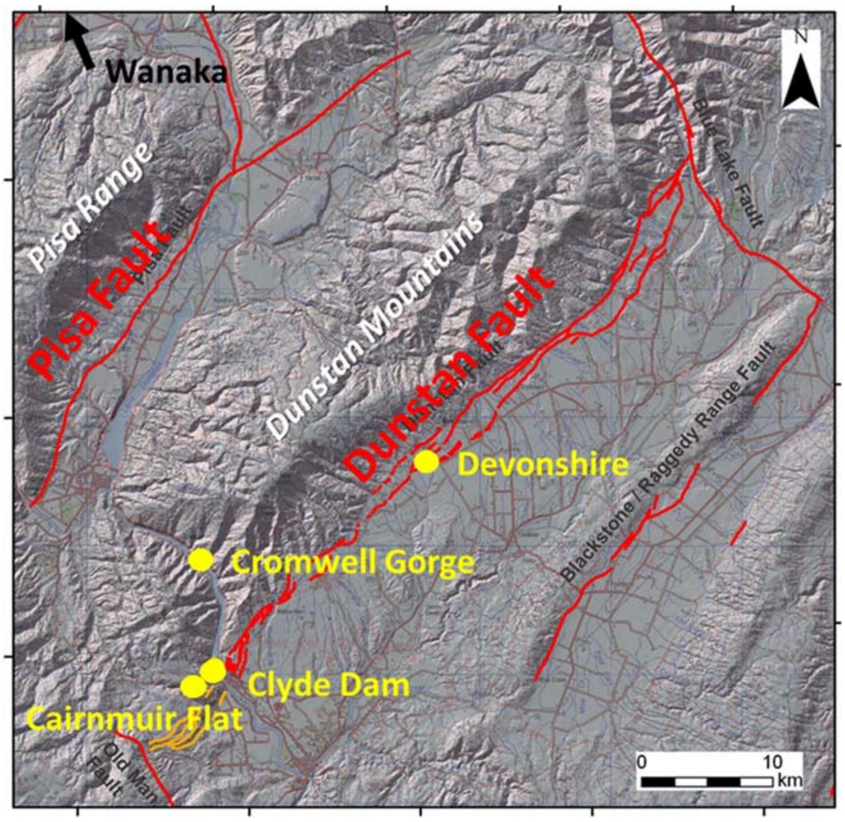

Figure 1: Key stops of the fieldtrip (Fault traces from the GNS Science Active Fault database, and topography from Google maps).

Wanaka to Cromwell

The trip departs from the Lake Wanaka Centre at 8.00am and heads towards Cromwell on State Highway 6. The drive from Wanaka to Cromwell mainly follows the western shore of the upper reaches of Lake Dunstan, the reservoir produced by the damming of the Clutha River behind the Clyde Dam in the early 1990s. The area inundated is the Upper Clutha Valley, one of the many fault controlled valleys of the central Otago contractional “Range and Basin” province. This name was coined some decades ago to distinguish it from the extensional Basin and Range province in the western USA. The Otago region is characterised by a network of reverse faults and folds, each accommodating a small component of the transpressional motion across the Australia-Pacific plate boundary. The smooth summits and slopes of many of the ranges are due to the preservation of the central Otago peneplain, a Tertiary erosion surface that has been variably displaced by the faults and folds of the province.

The early part of the Wanaka-Cromwell journey traverses Late Pleistocene moraines, meltwater channels and outwash plains associated with the ‘Albert Town’ advance of the Wanaka Glacier. About 1 km after Wanaka Airport, the road drops onto the younger ‘Hawea’ advance outwash plain, sitting ~40 m lower than the ‘Albert Town’, and emanating from the youngest of the Late Pleistocene moraine belts enclosing lakes Wanaka and Hawea. Down-valley from Luggate township, the road traverses the terraced flank of the upper Clutha valley along the eastern foot of the schist massif of the Pisa Range. The valley flank comprises a flight of glacial outwash terraces of different ages and interspersed alluvial fans that are variously trimmed by or aggraded over the outwash terraces. Down-valley of Albert Burn at Queensbury, ~28 km from Wanaka, the road climbs onto ‘Luggate’ age (late Middle Quaternary) outwash and fan terraces, with notable weathering evident in road cuts, before descending back onto the suite of Late Pleistocene terraces and fans for the remainder of the way to Cromwell.

Cromwell to Clyde

We will travel through the Cromwell Gorge from Cromwell to Clyde, and observe the landslides and associated remedial works undertaken to stabilise the landslides prior to the filling of Lake Dunstan (Fig. 2). The Cromwell Gorge is an antecedent gorge formed by down-cutting of the Clutha River during uplift of the Dunstan Mountains (to the east) and Cairnmuir Mountains (to the west). The landslides have developed in response to the uplift and incision, and became the foci of major investigations and remedial work in the late 1980s to early 1990s. The landslides contrast significantly in terms of size, geomorphology and mode of failure, and have shown variable rates of activity in time and space. We will stop to observe the Cairnmuir Slide and associated remedial work undertaken to stabilise this landslide. During the drive from Cromwell to Clyde we will also point out other significant landslides, such as the Cromwell Slide, and the massive Nine Mile Creek Slide. After a quick photo stop at the Clyde Dam lookout we will proceed through the township of Clyde, across the Clutha River, and to the Clyde Dam parking lot. Keep an eye out for movie star Sam Neill as you pass through Clyde. He owns property in the area, and is occasionally seen in town picking up a Jimmy’s pie and a six pack of Speights.

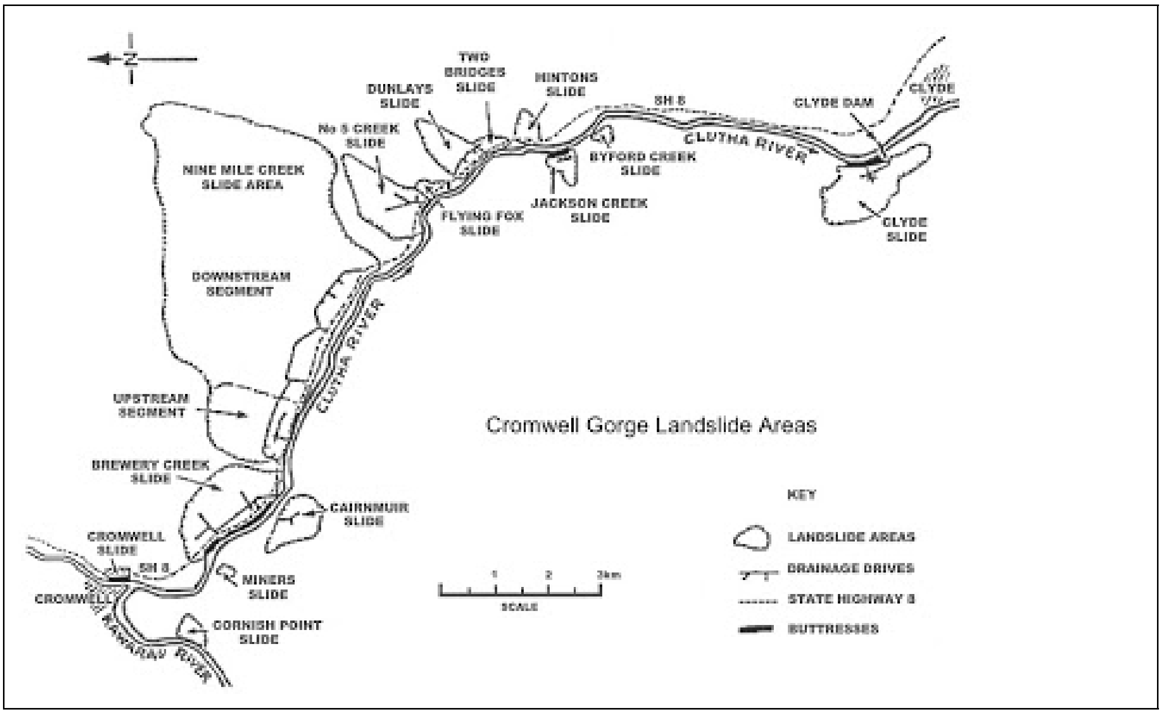

Figure 2: Cromwell Gorge landsides (Source http://mightyclutha.blogspot).

Clyde Dam Tour

The Clyde Dam is the largest concrete dam in New Zealand and provides a significant component of electricity to the national grid (Fig. 3). Completion of the dam project in the early 1990s followed extensive investigations of active faults in the area, and the investigation and stabilisation of landslides in the Cromwell Gorge. The dam sits at the downstream end of the antecedent Cromwell Gorge, and is upstream of the reverse-slip Dunstan Fault. The Dunstan Fault is responsible for uplift of the Dunstan Mountains, and is the most significant contributor to seismic hazard at the dam site.

Courtesy of Contact Energy Ltd we will be taken on a tour of the dam for a period of about one hour. The tour will take in the control room, powerhouse, and the slip joint within the dam. The slip joint was designed to accommodate 1-2 m of slippage on the River Channel Fault, which was discovered during dam foundation excavations. After visiting the dam site we will travel to Clyde to pick up some lunch.

Figure 3: The Clyde Dam (Photograph by Mark Stirling)

Clyde to Cairnmuir Flat

The trip proceeds back across the Clutha River and ascends Hawksburn Road to the Clyde lookout. At the lookout we will look out along the range front of the Dunstan Mountains and see the southwestern-most traces of the Dunstan Fault. The history of investigations on the fault will be briefly described. We will then proceed up to Cairnmuir Flat, a peneplain plateau remnant studded with spectacular schist tors, many with precariously-balanced rocks (PBRs) present (Fig. 4). The road beyond the Clyde lookout is not suitable for road vehicles, so participants will be ferried up to the next stop in a 4WD vehicle if we don't have enough 4WD vehicles to go up all at once. Once on the plateau we will visit at least one of the PBRs. The location of the ancient PBRs close to both the Clyde Dam and Dunstan Fault provides important constraints on near-field ground motions from the fault. An intensive programme of cosmogenic dating of the PBRs, and an assessment of the associated fragilities (ground motions required to topple the PBRs) has been conducted in recent years, and represents a world-first for PBR research being used in a commissioned seismic hazard assessment. The PBR fragility ages (time since the PBRs obtained their present unstable geometries) range from c. 20-70kyrs, which means that they provide significant long-term constraints on local seismic hazard. After seeing the PBRs, we will travel back down Hawksburn Road to Clyde.

Figure 4: One of the PBRs at Cairnmuir Flat. The narrowest part of the tor marks the boundary between the PBR and pedestal (Photograph by Mark Stirling).

Clyde to Devonshire

We will travel northeast to the Devonshire area of the central Dunstan Fault. This is where the majority of paleoseismic data have been gathered for the Dunstan Fault during two generations of Clyde Dam seismic hazard assessments (Figs. 5-8). As we approach the Dunstan Mountains range front on Devonshire Road we will cross scarps of the Dunstan Fault. The findings of the paleoseismic work will be discussed at the road end. We will end the day with the drive back to the Lake Wanaka Centre.

Figure 5: View northeast along the Dunstan Mountains range front and Dunstan Fault. Scarp features are accentuated by the shade lines in the middle of the image (Photograph by Lloyd Homer)

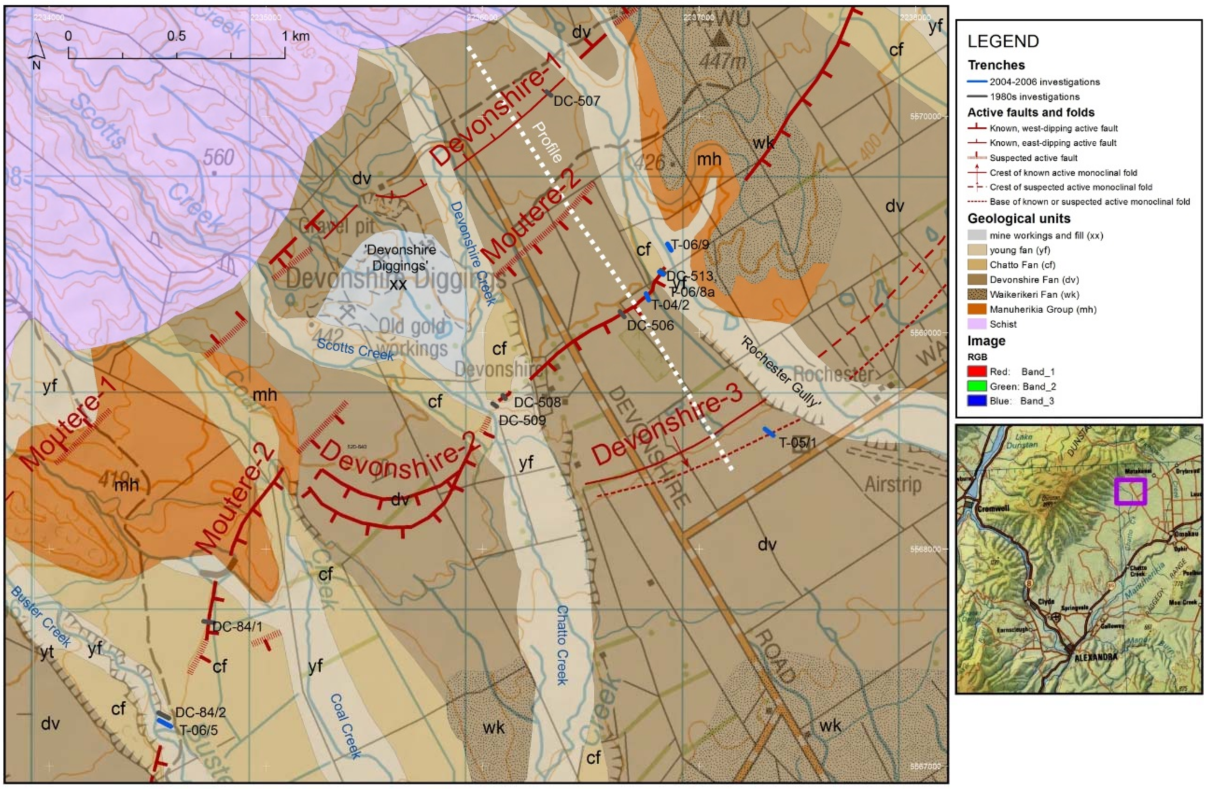

Figure 6: Geological map of the Devonshire area

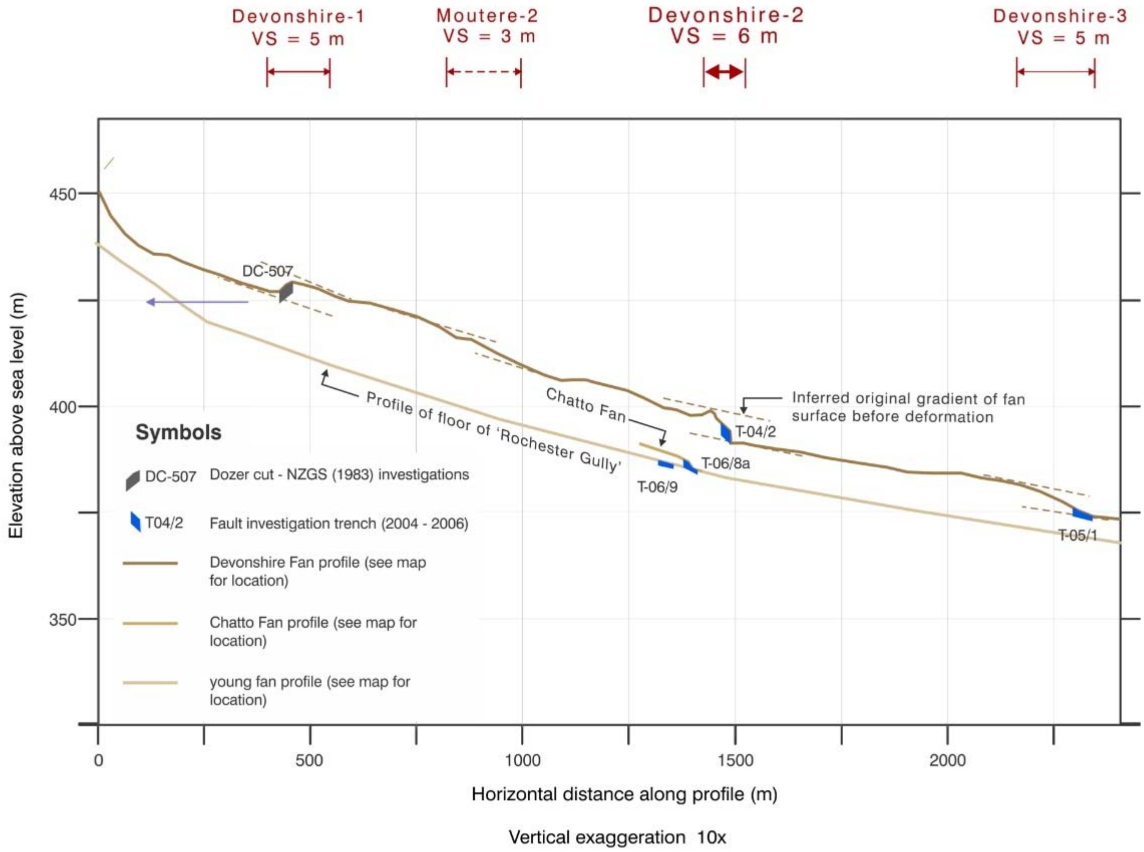

Figure 7: Profile of the Devonshire area

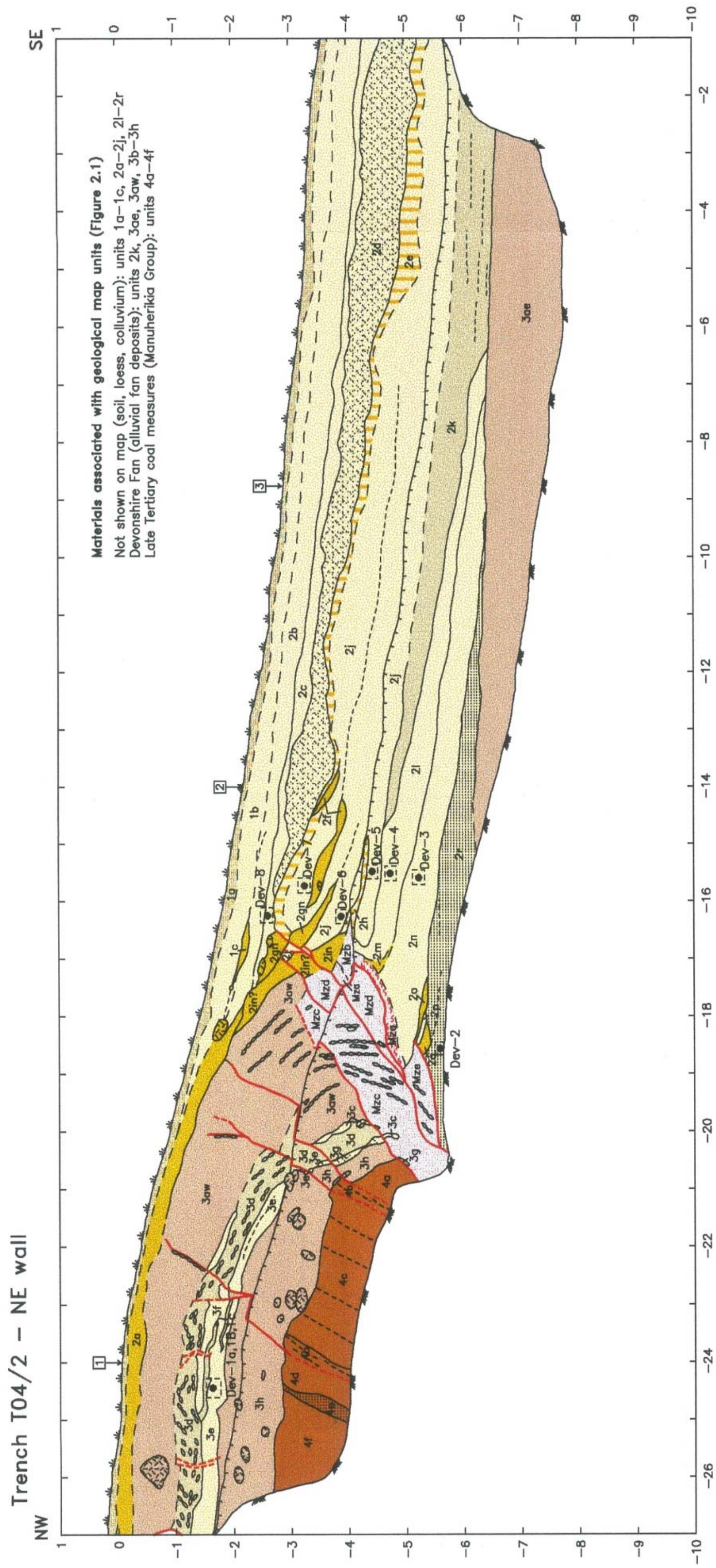

Figure 8: Log of fault investigation trench T04/2, Devonshire.