Spatial variability and the Extended Column Test (ECT): Results from Mt Hutt

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In early July 2009, Dr Karl Birkeland visited New Zealand with the support of a Fulbright Senior Specialists Program Award. As part of this visit, we had hoped that conditions and time would allow for us to undertake some research related to spatial variability, with a particular emphasis on the Extend Column Test (ECT). This work was a continuation of some earlier work we undertook in Montana back in February 2008 (Hendrikx and Birkeland, 2008; Hendrikx et al., 2009). We wanted to focus on the ECT as it is a relatively new test indexing fracture initiation and propagation, both of which are required for avalanching. As July approached with the combination of an early season unstable snow pack and the forecast new snow, I knew we would find something interesting to look at.

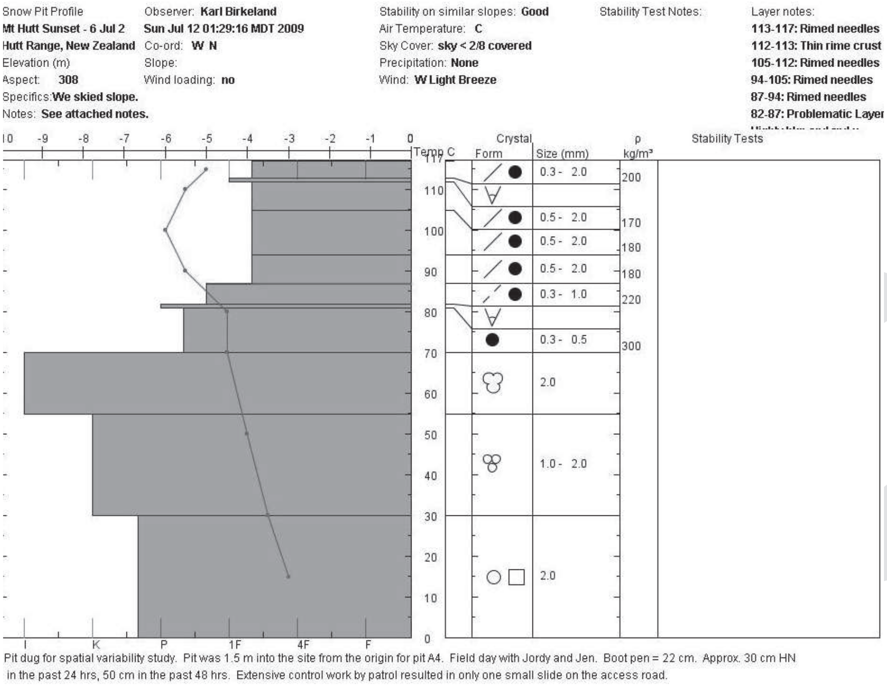
On July 6th we arrived at Mt Hutt Ski field. They had just had 50cm of new snow in the last 48 hours from the south east. This new snow had landed on a rime crust, which overlaid some partially decomposing new snow over that early season translucent ice layer. We were sure that there would be a good weakness in this pack, we just weren't sure if we could get at it. The study slope was off the back side of Mt Hutt, on a 30-35% north west facing slope, lee to this recent snowfall. Doing any snow science is a delicate business, as we ideally want it to be as unstable as possible but not so unstable that we get avalanched off the slope. Making this basic error would make us good candidates for the Darwin Awards. We spoke to Ski Patrol, who had been bombing that morning and despite several attempts (even with large 12.5kg charges) only two avalanche were triggered – a size 1 on a 30% slope, south easterly aspect & and a size 1.5 on a 37% slope south easterly aspect (Avalanche.net.nz). Looking up at the mid towers slope we could see evidence of their morning's work, with bomb craters littering the snow. This was not too surprising as Patrol had noted that the 50cm of new snow had settled down to 32cm as it was falling – i.e. a pretty high settlement rate.

We headed up and tentatively headed onto the north west facing slope – using our probe, we established that the new snow overlying the rime layer was about 50cm deep and following a couple of quick tests, combined with other observations, we were satisfied that the instability was not too touchy and that we could safely work on this slope.

We laid out a grid of 30 snowpits 10m apart, with 6 snowpits down the slope and 5 snowpits across. In each snowpit we recorded snow depth, depth to weakness and completed one Compression Test (CT) (Jamieson, 1999) and one Extended Column Test (ECT) (Simenhois and Birkeland, 2006; Simenhois and Birkeland, in press). In an attempt to standardise the testing as much as possible we laid out each pit identically and one person did all the tests on the slope. A full snowprofile was also made on the edge of our grid (Fig. 1). The weakness that we were interested in was actually within the storm snow at a subtle density change, not on the rime layer as we had anticipated. As the day progressed, we started to notice that the ECT test was consistently not propagating across the column – i.e. ECTN – indicating generally stable conditions. However, at the same time, the CT was providing low to moderate test results. In some cases there was as much as 17 taps different between two adjacent spaced tests (e.g. CTE2 next to CTM19). The results of the CT and ECT for July 6th, are shown in Figure 2. The number are the CT scores and the shading indicates if an ECT propagated (i.e. ECTP).

When you consider Figure 2, you can see that there is a large range in the CT test scores and that there is not an obvious spatial pattern to the scores. There is also not a clear connection between the CT and ECT test results – i.e. the ECTP did not occur on the lowest CT scores, as one might expect. By contrast, the fracture character/quality of shear in the CT were very consistent, with resistant planar, Q2 shears being observed for 29 out of the 30 tests. Had there been more Q1/sudden planar, or Q3/Breaks, then the quality of shear/fracture character could have been the parameter that helped delineate the message provided from the CT scores.

Now let's consider the case of a forecaster/patroller/avalanche professional, that approached this slope. If they approached this slope from the top (i.e. A6-E6) and completed one CT test they could have got a score of CTE4 to CTE8, with a second test along this slope providing another result in the same range. Given these scores and the substantial amount of



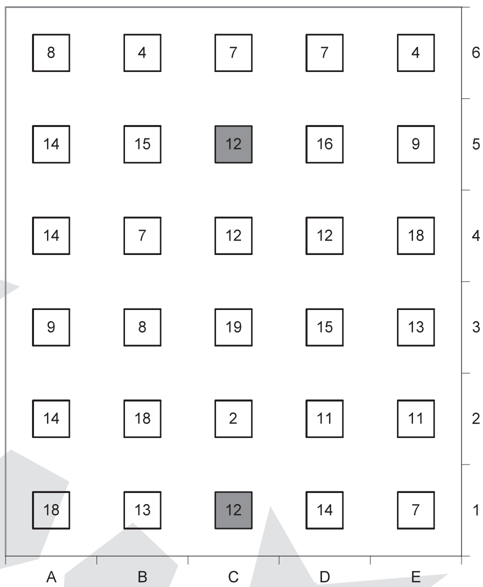


Figure 1 – Snowprofile at Mt Hutt on 6 July, 2009. North west aspect, elevation 2020m.

Figure 2 – Snowpit grid on 6 July, 2009 at Mt Hutt. The numbers are the CT scores and the shading indicates if an ECT propagated (i.e. shaded equals ECTP)

new snow, many would have considered this slope to be "unstable" on what was considered to be a stable slope (i.e. a type II error). If we now consider the person approaches the slope from the bottom (i.e. A1-E1) and completes two tests along the slope, then they would have got score of CTE7 to CTM18, providing an even less clear picture of the slope stability. Depending on where they approached the slope, the information provided to them via the CT would be very spatially variable. Now let's consider this statistically, if we suggest a score of 13 as the boundary for unstable/stable for the CT (this could be debated at length, but 13 has been used elsewhere e.g. Schweizer and Jamieson, 2003, where CT scores ≤ 13 were classified as "poor"), then we would have 63% (19 of the 30) of the CT scores are at or below the threshold of 13. So on average, if one approached this slope they would be more-likely-than-not to obtain a CT score at or below the threshold value, indicating an (incorrectly assessed) unstable slope. By contrast, if we consider the ECT results, then only 7% (2 of the 30) of the ECT results propagated, indicating an (incorrectly assessed) unstable slope. On average on this slope, you would have had a 1-in-15 chance to obtain an ECTP, indicating an (incorrectly assessed) unstable slope. Alternatively, one can also consider the number of results that would have provided information consistent with the observed slope stability – i.e. only 37% (11 of the 30) CT scores provided a CT result greater than 13, while 93% (28 of the 30) ECT results did not propagate.

In summary, on this day, on this slope, you would have been almost ten times more likely to have obtained a CT score that would have incorrectly suggested an unstable slope (i.e. false unstable), compared with if you had used the ECT results. Studies elsewhere (e.g. Simenhois and Birkeland, 2006; 2007) have also identified the low false stable and unstable rate with the ECT. This can be attributed to the fact that the ECT attempts to index both the facture initiation and fracture propagation potential and both are required for avalanching. So, while you may be able to initiate a facture with the CT, it may not propagate.

There has been some concern in the past about how well the ECT would work in New Zealand snow conditions. However, some of the original work on the ECT was conducted in New Zealand at and around Mt Hutt (Simenhois and Birkeland, in press). In addition to those data, this dataset suggests that the ECT is a useful and reliable test to add to the suite of tests in the bags of tricks for NZ avalanche forecasters and the only test to index fracture propagation.

Acknowledgments

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A New Weekly Avalanche Workshop ran this winter in Wanaka to help promote avalanche safety

The Mountain Safety Council's Wanaka Branch developed an informal setting giving backcountry users the opportunity to get questions answered by top avalanche professionals on a weekly basis. Kindly supported and hosted at Mainly Tramping's store in the Spencer Mall on Dunmore St, each week it featured:

- A wrap up of current weather, snowpack and Avalanche conditions from www.avalanche.net.nz
- a short presentation/led discussion on the themed topic for the evening
- a question and answer session

The regular and relaxed format helped build a community of backcountry users where people:

- Participated in a less intimidating setting compared to the big one-off seminar (many regions currently run)
- Could be referred onto courses
- Shared their experience or teamed up with others that have more experience
- Shared rides/split costs – more sustainable
- Promoted the exchange/reporting of information

The evenings were held on a Thursday so the weekly advisory could be used as a reference and so that people could plan towards trips over the weekend.

In all but the last few weeks of September there were between 20-30 people at each evening. Every week there were some new people.

Each week, the facilitator would start a discussion of what trips people had been out on during the past week, questioning and drawing out of them any observations (avy, snowpack, weather) they had made. After putting their lay speak observations into more technical speak, the discussion turned to the INFOEX advisories, which reflected and backed up the group's own observations.

DVD and other media were also used as a resource (Fine Line) after which a discussion (question and answer) reinforced the points covered in the DVD.

Evenings lasted up to 1hour.

Thanks to Steve at Mainly Tramping for hosting the workshops.

Gordon Smith