# GSA Data Repository item 2002124 to accompany: Paleoseismology at high latitudes: seismic disturbance of late Quaternary deposits along the Castle Mountain fault near Houston, Alaska

## Introduction

This Data Repository consists of more complete descriptions of trench logs referred to in the main text of the manuscript. The figures and references discussed herein are those in the main manuscript and they are not duplicated here.

## Observations in Trenches

*Trench 1*

Trenches 1 and 2 had broadly similar structural and stratigraphic characteristics with a thrust fault at the base of the scarp and few liquefaction features (Figs. 4A, B). Both trenches were located about 100-m apart on a splay of the CMF about 0.7 km west of the Parks Highway (Fig. 2). Trench 1 had one main zone of thrust faults at the base of the topographic scarp at 21-25 Feet (Fig. 5A), and another possible fault, 2 m further to the south at 28-34 Feet (Fig. 4A). Between 21 and 25 Feet were two main faults, with a minimum of 40 and 42 cm of offset on each. However, the strata are not correlative across the northern fault, which implies more (≥ 1.0 m) offset. The upper and lower paleosols in the zone of thrusts are correlative as indicated by similar radiocarbon ages (3680±40 $^{14}$C yr B.P. and 3780±60 $^{14}$C yr B.P., Table 1). Therefore, offset on the southernmost fault at the base of the scarp would be a minimum of1.0 m. Total offset on all faults would be ≥ 2 m.

Thrust faults were identified by slight variations in color along inclined linear zones of offset, but were difficult to see in the top of the till, and impossible to see near the bottom of the trenches. We did not observe clay seams, slickensides, or planar partings along any fault surface. This is due in part to the lack of clay- and silt-sized sediment in the till. In some locations, silt caps clasts in the till were no longer on top of the clasts along the downward projected trend of the thrust faults (Fig. 4A). Because these silt caps always form on the top of the clasts, their location on the sides indicates the clasts were rotated after they formed, probably during faulting.

Several other features indicated thrusting or liquefaction. A subtle pedogenic horizon with tabular structure near the base of frost-rotated cobbles was folded and offset by the thrust faults. A 25-cm deep, 5-cm wide infilled ground crack at the crest of the scarp at 9 Feet, was filled with loose sand, and the bottom had loose pebbles (Fig. 4A). We infer this crack developed by extension, as the hanging-wall sediments were thrust onto the surface and sagged downward south of the crack. Between 28-31 Feet, till forms one large, and two smaller, bifurcating dikes that cut across weak layering in the loess. The dikes were tabular and paralleled the fault scarp. Another meter south of these liquefaction features, at 33 Feet, a large ball of loess partially sunk into the underlying till with a morphology similar to a ball-and pillow structure. For the loess to have sunk into the till, it implies that the till was cohesionless and flowed, and also indicates liquefaction. The loess (silt) above these features probably acted as a low permiability cap aiding liquefaction. Above the liquefaction features, the loess was very thick - about 97 cm, whereas just to the north, it was only 27-cm thick. Because the change in thickness occurred just above the zone of liquefaction, there may have been faulting associated with liquefaction that eliminated part of the loess section to the north, or tripled its thickness to the south. It is plausible that at least an additional 60 cm of offset occurred in this zone.

*Trench 2*

Trench 2 had a thrust fault, a strike-slip fault, and one liquefaction feature (Fig. 4B). The liquefaction feature was a pancake-shaped diapir of till, which intruded the base of the loess, about 1 m north of the vertical fault zone between 25-27 Feet. This till had a sandy matrix, and the intrusion cut across stratification in the loess.

Two main structural zones were mapped in Trench 2. The most significant was near the top of the scarp between 22-23 Feet, where we infer a vertical fault zone 30-40 cm wide is a strike-slip fault (Fig. 5B). Loose sediment in the fault zone allowed unusally deep penetration of tree roots to more than 1.5 m depth. On either side of the fault zone, the sediment was unusually compact. One to two meters to the south, between 12-19 Feet, a thrust fault dipping 48° N at depth, gradually shallowed to 13° N about 1 m below the ground surface. Loose gravel at the toe of the thrust was buried by the modern soil and interfingered with the loess. This may be a colluvial deposit related to a paleoseismic event. The total offset on the thrust, based on offset of the loess-till contact, was 1.1 m. A few fractures were present south of the main thrust between 8- 15 Feet. Most did not have any offset, but the northernmost fracture offset the loess-till contact ~12 cm. One large fracture was present in the loess between the vertical fault and thrust fault zones at 18 Feet. This feature dipped south and accommodated extension of the loess as it was thrust over the bend in the thrust fault. Taken together the strike-slip and thrust fault zones indicate transpressional deformation.

A planar zone of disrupted layering in the loess defines a minor fault zone at the north end of the trench. Disruption of tephras just above this horizon indicates a north-dipping thrust fault. The basal contact between the loess and the till was vertically offset only 20 cm. The modern soil horizon overlying the fault zone was not disturbed, as at the south end of the trench. We infer that this zone is probably the same age as the structures to the south.

Radiocarbon dates place tight constraints on the timing of fault movement. Wood in a weakly developed paleosol overriden by a thrust fault at 16 Feet yielded a radiocarbon age of 3160±60 $^{14}$C yr B.P. (Table 1). Charcoal fragments from four samples in loose sediment that fell into the vertical fault zone at 22.5 Feet, gave radiocarbon ages of 2470±40 $^{14}$C yr B.P., 2600±60 $^{14}$C yr B.P., 3090±40 $^{14}$C yr B.P., and 4420±50 $^{14}$C yr B.P. (Fig. 4B, Table 1). An AMS date on charcoal from the basal A horizon overlying the vertical fault zone at 22 Feet yielded an age of 2670±50 $^{14}$C yr B.P., which indicates faulting occurred prior to that time. The age of the charcoal from the basal A horizon (T2C6) is slightly older than the age of the youngest dated material in the fault zone (T2C4). Thus, the last rupture occurred around the interval between the dates – approximately 2470-2600 $^{14}$C yr B.P. (roughly 2730-2740 cal yr B.P.; Table 1).

*Trenches 3 and 4*

Trenches 3 and 4 were about 75 m apart (Fig. 2) and both were characterized by pervasive liquefaction south of the scarp (Figs. 4C, 4D). Fluvial gravel at the base of both trenches was overlain by eolian sand and loess. From the base of the fault scarp southward, numerous sand intrusions and widespread disruption of the stratigraphy indicates liquefaction (Fig. 5C). The sand intrusions rose to the base of the lowermost soil

A horizon, and cut across, but locally parallelled lower stratification and stratigraphic contacts (Fig. 5D). The distal ends of the intrusions were lobate, and their contacts undulatory. The long axes of pebbles in the injections roughly paralleled the margins of the injections. The sand intrusions are probably liquefaction features as indicated by their morphology, their cross cutting contacts, parallelism between intrusion walls and clasts in the intrusions, and their tabular shape. Additionally, these sediments were water saturated at the time of trenching, they lack clay and silt, and had a cap of loess (silt), all of which contribute to ideal conditions for liquefaction. The zone of liquefied sediments extended at least 4.3 and 5.2 m south of the base of the fault scarp in Trenches 3 and 4, respectively. The widespread and shallow disruption, which extended up to the base of the root mat, suggests that liquefaction occurred when the ground was thawed, probably in the summer.

The main fault zone in both trenches was probably located at the north end of the zone of pervasive liquefaction. In Trench 3, the contact between sand and gravel, near the base of the trench between 27.5 and 29.5 Feet, was planar and could be a fault surface. Another fault surface in Trench 3 was present above the lowermost silt between 31 and 36 Feet. In Trench 4, we infer a fault just south of a sand horizon in the fluvial gravel at 19 Feet. This location coincides with vertical offset of the loess-gravel contact and also coincides with the base of a zone of Fe-oxidized sediment displaced 0.5 m to the south. In addition, a radiocarbon age of 5460±40 $^{14}C$ yr B.P. from charcoal in a loess horizon at 19.5 Feet overlies a sand block (discussed in the following paragraph) with a date of 3690±60 $^{14}C$ yr B.P. Thus, the reverse stratigraphic order of the radiocarbon ages is consistent with a contractional fault, which moved in the last 3690±60 $^{14}C$ yr B.P.

The amount of dip-slip offset on the faults cannot be precisely determined due to the lack of a well defined fault and the disruption of strata across the fault zone. However, vertical offset of stratigraphy provides a minimum for fault displacement. In Trench 3, the loess-gravel contact was vertically offset approximately 85 cm, and in Trench 4, it was harder to estimate. The loess is duplicated at 19-20 Feet, with the base of the loess offset 35 cm.

We found evidence for multiple liquefaction events in both trenches. This was perhaps best seen in Trench 4 in a sand block dated at 3690±60 $^{14}$C yr B.P., at 0.9 m depth between19 and 20 Feet, where a sand dike cut a sand block, but did not extend beyond the block margins. This relation indicates that a subsequent liquefaction or deformation event isolated the block and dike from its original position. In addition, a number of liquefaction intrusions cut across older ones. In Trench 4, an injected sand that cuts the lowermost soil A horizon at 20 Feet also cuts another intrusion beneath it. Another injection, at 20.8 Feet, cuts across intrusions north and south of it. The large deeper injection at 23 Feet intrudes a higher, older one. In Trench 3, the injection between 29 and 30.5 Feet cuts an older intrusion. The highest injection at 36 Feet cuts an older intrusion. Several fingers of sand between 39-42 Feet may have intruded previously deformed sediment. Lastly, the basal soil A horizon in Trench 3 cuts across laminae in the uppermost loess between 35 and 38.5 Feet.

Radiocarbon ages provided constraints on the age(s) of liquefaction. An isolated pod of peat in Trench 3 from 41-42 Feet was the remnant of an older A horizon, and was dated at 2300±70 $^{14}$C yr B.P. A similar feature in Trench 4 yielded a 4250±70 $^{14}$C yr B.P. age. Soil-organic matter from a paleosol above the peat in Trench 3 yielded a radiocarbon age of 2000±40 $^{14}C$ yr B.P. Thus, we infer that a liquefaction event occurred in the interval 2300-2000 $^{14}C$ yr B.P. Additional ages from Trench 3 of 3750±40 $^{14}C$ yr B.P. and 1910±40 $^{14}C$ yr B.P. on charcoal in deformed paleosols indicate at least one liquefaction event younger than these dates. Radiocarbon ages on basal soil A horizons superjacent to liquefaction features suggest a liquefaction event younger than 660±50 $^{14}C$ yr B.P. (sample T3C8) and 870±40 $^{14}C$ yr B.P. (sample T4C9; Table 1).

*Trench 5*

Trench 5 was located along one of the most spectacular vegetation lineaments of the CMF (Fig. 2). It had a small (~45 cm) scarp, however, no faults were found in the trench (Fig. 4F). The deposits exposed in Trench 5 consisted of about 2 m of peat, overlying fluvial sand and gravel of unknown thickness. The water table was close to the ground surface (within about 0.5 m), and the trench walls became unstable and collapsed in about 3-4 hours. A prominent 3-6-cm-thick tephra was discontinuously present along the entire length of the trench. The tephra bed was 55 cm lower at the south end of the trench than the north end. The source of the tephra is not known, but a likely candidate is Hayes volcano. The Hayes tephra is the thickest and most widespread Holocene tephra in the Susitna lowland, and erupted about 3500 $^{14}C$ yr B.P. (Riehle, 1985; Riehle et al. 1990).

Although there were no fault traces in the trench, north-side-up movement of the fault is probably responsible for the surface topography, and some of the variation in depth to the sand-peat contact and to the tephra bed. Assuming that the sand-peat contact was initially horizontal, about 0.98 m of vertical offset occurred on the fault. However, all of this motion would have to have been accommodated by structures beneath the observed section. Beneath the vegetation lineament, a small bulb of gravel extended into the base of the peat. We interpret this as a liquefaction feature based on its morphology and because it cut stratification in the peat. The oldest radiocarbon age from any of the trenches came from the base of the peat: 9950±50 $^{14}C$ yr B.P. This is close to the ca. 11,400±720 $^{14}C$ yr B.P. age of deglaciation for this area (Reger et al., 1995d). Assuming a constant rate of deposition for the 1.65-m-thick section and the average of the calibrated ages of 11,390 cal. yr. BP, the average peat accumulation rate for this section was 0.14 mm/yr. The vegetation lineament on the fault scarp may have developed because it is topographically higher and not as wet as the surrounding area. Soils on the scarp would thus be better drained and less acidic, and would allow growth of spruce trees on the fault scarp (K. Boggs, oral comm., 1994).

*Trench 6*

Few liquefaction features, elusive evidence of a fault, and an enigmatic cobble deposit characterized Trench 6. It was located about 450 m east of Trench 5 on a topographic high associated with a subtle lineament in spruce trees along the fault trace. There was no scarp. Liquefaction features were present in six places, but there were no offset strata (Fig. 4E). The fault was probably located at about 13 Feet, where bulbous structures, composed of sandy-matrix till, extended into the base of the modern soil. We interpret these as liquefaction features because of the shape, and because the margins of the features cuts stratification in the loess as well as the loess/A horizon contact. Evidence of offset in the unstratified till could not be found. On the opposite wall of the trench, another sandy-matrix bulbous liquefaction feature extended into the base of the modern soil, where a fault zone was also not observed. Minor differences in clay content of the till across a possible fault boundary may indicate a small amount of displacement.

Two unusual lenses, up to 0.75 m thick, of clast-supported cobbles in a matrix of dark gray organic-rich silt were exposed in Trench 6. Frost heaving is a possible mechanism for transporting cobbles to the surface, but this process probably would not concentrate the cobbles into pockets. Because the cobbles were clast supported, they might be a lag deposit. However, the trench was on a topographic high, and if a lag was produced by river-related fluvial activity, water would have eroded the soft loess beneath the cobbles and left a more pronounced deposit. It is conceivable that the cobbles are remnants of a liquefaction deposit. The cobbles in their organic-rich silty matrix were similar to some features in Trench 7, at the upward extent of liquefaction injections.

At the time of trenching, the water table was at the bottom of the trench, but gleyed zones in the till, below a depth of 80 cm, indicated the water table had been higher. Fe-

Mn stained sediments, between 4-18 Feet, indicated oxidation in the vadose zone. Fe-Mn stained sediment crossed the inferred fault location. If the water table was commonly deeper at this locality than at the other trenches, as we observed, the greater depth of the water table may be the reason for the lack of abundant liquefaction features.

*Trench 7*

Trench 7 had widespread liquefaction of till, and the only evidence of sand blows, which we infer was due to unusual local vegetation and the mechanical properties of its root mat. This trench was located 1.2 km southwest of Trench 5 along a prominent fault scarp and vegetation lineament about 0.25-m high. Vegetation on the north side of the scarp was closed-canopy black-spruce forest, but the south side of the scarp consisted of a bluejoint meadow (Viereck et al., 1992) with unusual bluejoint tussocks (*Calamagrostis canadensis*). Bluejoint tussocks have dense roots and wet inter-tussock low areas that generally lack a rooty substrate. The tussock roots did not form an areally extensive interlocking root mat, as did the spruce and birch roots in all other trenches. During wet periods, the low areas between tussocks (e.g., between 35-38 Feet, Fig. 4H) were filled with water, promoting deposition of dark gray organic-rich silt (Fig. 5E). Cobbles and boulders in organic silts were observed at the ground surface within 2-3 m south of the scarp.

It was not possible to determine the exact location of the fault in the trench walls despite the prominent vegitation lineament it crossed (Fig. 4H). Aside from what we interpret as widespread liquefaction-induced deformation, we only found a broadly folded zone in the till at the location of the fault scarp. It is possible, but not necessary, that the folding reflects deformation above a fault-propagation fold. If so, the tip of the fault would need to be very shallow.

Liquefaction features were common along the length of the trench walls. Stoped blocks of stratified loess were surrounded by till were found at the 5, 6-10, 22.5-24.5, and 32 Foot locations (Fig. 5F). Stratification in a loess block at 5 Feet was tilted almost to vertical. The sandy-matrix till cut across stratification in the loess in numerous places and had dike, sill, mushroom, and fork-shaped contacts with the loess (Fig. 5G). A large clast in a liquefaction feature on the unmapped east wall of the trench, was apparently rotated to vertical after injection (Fig. 5H). Assuming this liquefaction feature is the same age as another feature (discussed below), rotation of the cobble occurred in the last 2315-2710 cal. yr B.P. We interpret the discordant contacts, the morphology of the margins of the till, and the tabular shape of the dikes and sills as originating from liquefaction. An irregularly shaped deposit of pebbly sand in the middle of the loess unit at 35-36 Feet was probably a liquefaction feature because its amoeba-like shape was similar to other liquefaction features with conduits that could be traced downward.

Liquefied sediment may have extruded onto the surface at three locations. The clearest of these was opposite 28 Feet on the unmapped east wall of the trench. Here an injection composed of till extended above the lowest paleosol with a radiocarbon age of 2370±60 $^{14}$C yr B.P. (Fig. 5I). The till above the paleosol was traced laterally downward into the main body of till on the trench wall. The paleosol was traceable upward, where it merged with the base of the modern soil A horizon. Conventional analysis of soil-organic matter from the base of the overlying modern soil yielded modern radiocarbon, but an AMS analysis on charcoal from the same sample produced an age of 360±70 (Table 1).

Unfortunately, these dates only loosely constrain the timing of the paleoliquefaction event.

The other two possible sand blows were at 14.5-16.5 and 20.5-21 Feet where lenses of sandy sediment overlay the lowermost soil A horizon. The sand lenses pinched out laterally, and did not have lobate margins, as is typical of liquefaction features. Their location above the lowermost soil A horizon is unique, and thus, we infer the sand lenses are sand blows.

There are problems with radicarbon ages of peats that bracket the sand lenses. The peat enclosing the sand lenses at 14.5-16.5 Feet yielded AMS radiocarbon ages of 1770±50 $^{14}$C yr B.P. and 2060±60 $^{14}$C yr B.P., and peat samples associated with sand lenses at 20.5-21 Feet yielded radiocarbon ages of 60±40 $^{14}$C yr B.P. and 1430±40 $^{14}$C yr B.P. The dates are in the correct stratigraphic order, and might indicate two paleoliquefaction events in the intervals between the two pairs of dates. However, the soil A1 horizon overlying the sand lenses could be traced between the inferred liquefaction deposits, and both are about the same distance beneath the ground surface (Fig. 4H). Thus, based on soil stratigraphy, it appears that one, not two, liquefaction events produced the sand lenses. Several hypotheses may explain the observed relations and dates: 1) The two sand lenses indicate one paleoliquefaction event, and the 1430±40 $^{14}$C yr B.P. age is too young for an unknown reason. 2) There were two paleoliquefaction events, and an amalgamation surface in the modern soil A horizon went unrecognized. This would explain the correct stratigraphic order of both pairs of ages, and would not reject one of the dates. 3) One of the sand lenses was not ejected, but rather injected. The convex upper surface of the feature between 14.5-16.5 Feet may be consistent with this hypothesis. We expect ejected sand would have a planar and horizontal upper surface. We reject hypothesis (1) because we find no good reason to conclude that the radiocarbon age of 1430±40 $^{14}C$ yr B.P. is too young. We see no pathway to translocate young carbon into the sample, because it lay beneath the sand lens, and there was no root penetration. Hypotheses (2) and (3) are both consistent with the paleoseismic history from the other trenches.

Another unusual feature of this trench were cobble beds in a matrix of dark-gray organic-rich silt. The beds were located between 26-40 Feet (Fig. 4H), and were similar to those in Trench 6, but the clasts were matrix supported. There was no local topography from which these clasts could have been derived, and there was no evidence, such as found in Trench 8, for cobbles having been frost-heaved upward through the loess. We suggest that these deposits formed by upward transport of till during liquefaction. The cobbles were likely derived from the liquefied till, because they were found up dip from a younger set of liquefaction features. Soil formation and frost mixing after liquefaction may have introduced organics into the sediment. Several depressions in the top of the loess surface between 33.5 and 38 Feet were also filled with cobbles and organic silt. Moreover, cobbles were abundant in the lowermost soil A horizon at the north end of the trench between –1 and 13 Feet, and the cobbles between –1 and 7 Feet were above loess.

Assuming it was a liquefaction event that brought the cobbles to the surface, it probably occurred prior to development of the modern soil A horizon, because almost all of the cobbles lay below it. At 26 Feet, liquefaction structures composed of till cut across the contact between the dark-gray silt with cobbles and loess. An AMS analysis on a sample of the organic-rich silt at 30.5 Feet yielded an age of 2440±50 $^{14}$C yr B.P., and is probably older than the liquefaction event.

Additional radiocarbon dates help constrain the timing of paleoliquefaction events. Two dates on soil-organic matter from the basal modern A horizon are140±40 and 1030±40 $^{14}$C yr B.P. These dates are from the same horizon with the previously discussed 60±40 and 1430±40 $^{14}$C yr B.P. dates. We infer both dates are younger than a paleoliquefaction event, because the cobble deposit with the organic-rich silt matrix lies beneath.

*Trench 8*

Trench 8 had localized evidence of liquefaction and no discrete fault trace (Fig. 4G). It was located on a scarp that cut a 1-m tall till-cored mound, approximately 75 m east of Trench 7 in an area of dense spruce forest (Fig. 2). We found no evidence for offset of any strata by any process other than liquefaction. Five liquefaction features were located at the base of, and south of, the fault scarp (Fig. 5J). We interpret five features located at the base of, and south of, the fault scarp as liquefaction features, because they cut stratification and E and $B_w$ horizons in the loess. The liquefaction features did not penetrate the soil A horizon, which had a particularly dense network of spruce roots. A stratification-parallel elongate blob of till surrounded by loess between 22.5 and 29 Feet appears to be a liquefaction feature, which had an out of plane conduit to the main mass of till. There is no other reasonable explanation for till in the midst of the loess. This till blob cuts a paleosol dated at 4080±40 $^{14}$C yr B.P. Another paleosol at 18 Feet was cut by a liquefaction feature dated at 2070±40 $^{14}$C yr B.P. The till in all the liquefaction features had a slightly sandy matrix and lacked significant silt and clay. Frost-rotated cobbles were particularly common in the liquefaction zones. Sand lenses within the till, as well as the morphology of the mound north of the fault trace, indicate it is an ablation till.

The largest frost-heaved clast in any trench was found at 38 Feet in Trench 8 (Fig. 5K). Here, a 60-cm long boulder, and a few smaller cobbles, had been transported at least 60-cm upward through loess, assuming the top of the boulder was originally at the top of the till. Contorted E horizons beneath the boulder reflect deformation in the wake of its upward travel.

*Trench 9*

Trench 9 had pervasive liquefaction in the upper part of the trench, a master thrust at depth, and two additional thrusts. It was located on a well-defined fault scarp about 0.85 km west of Trenches 7 and 8 (Fig. 2). The stratigraphy of the trench walls differed significantly from the other trenches (Fig. 4I). It had the thickest eolian sand of any trench, very little loess, which when present was interbedded with the sand. It also contained glaciolacustrine silt that overlay till (Fig. 4I). The stony silt had been gleyed, but was later oxidized, giving rise to a mottled appearance. Uplift of these sediments above the water table likely caused oxidation of the gleyed silts.

Liquefaction features were common and pervasive in the upper 1-1.5 m of the trench (Fig. 5L), and extended to at least 2-m depth. A large ball-and-pillow structure was between 16 and 19 Feet. Above this were flame structures as indicated by subvertical color banding in the sand. Two unusual injections of pebbles in a peat matrix were at the south end of the trench. North of the fault scarp, several paleosols and tabular liquefaction features dipped north (Fig. 5M). From the crest of the fault scarp to the south these features were subhorizontal, but in the uppermost 0.5 m of the trench, they were inclined northward. Evidence of more than one liquefaction event comes from between 23 and 27 Feet at the base of the sand, where an older, tabular liquefaction feature with a lobate end was cut by a younger one. Also, the ball-and-pillow structure around 16-19 Feet was cut by a younger liquefaction feature.

Radiocarbon ages of paleosols were critical for determining stratigraphic and structural relations at the north end of the trench. A south-vergent thrust fault, obscured by liquefaction, must lie between paleosols between 8.5 and 16 Feet dated at 1860±60 $^{14}$C yr B.P. and a paleosol between 2.5 and 9 Feet dated at 4010±40 $^{14}$C yr B.P. Another paleosol between –4 and 4 Feet yielded an age of 4150±40 $^{14}$C yr B.P. We infer a paleosol between –4 and 4 Feet with an age of 4150±40 $^{14}$C yr B.P. is correlative with the paleosol between 2.5 and 9 Feet, because the ages are similar. Thus, there is another obscured thrust lay between these paleosols, but it would lie above a paleosol between 4 and 8 Feet dated at 3710±40 $^{14}$C yr B.P. The thrust must have a minimum of ~1.0 m of offset, but if the fault plane paralleled the fabric in the sediments, offset is probably on the order of 2 m. These thrusts are 3-7 m north of the scarp-forming trace of the Castle Mountain fault, and possibly connect with an unmapped fault strand to the north. The angular unconformity between the modern soil and the underlying sediments indicates subaerial erosion after deformation (Fig. 5L). Dates on peat and charcoal from the modern soil are range from modern to 980±60 $^{14}$C yr B.P.

The lowermost modern soil (A2) horizon is an important marker because it both postdates older deformation and was intruded by liquefaction features (Fig. 4I). The base of the A2 horizon was unconformable with the paleosols beneath it at the north end of the trench, which indicates it is younger than the event that imbricated the paleosols. It was also discontinuous north of about 29 Feet, which indicates it was disrupted by subsequent deformation.

There are some inconsistencies with the three radiocarbon ages of the soil horizon: 730±40 $^{14}$C yr B.P.,1280±50 $^{14}$C yr B.P., and 2020±40 $^{14}$C yr B.P. The 2020±40 $^{14}$C yr B.P. age is enigmatic. This age is older than than the youngest age of a deformed paleosol (T9C13, 1860±60 $^{14}$C yr B.P.). We suggest either this soil A horizon is a remanent that predates deformation, or the sample was biased by old detrital carbon. Also, a 980±60 $^{14}$C yr B.P. date on the basal O horizon at 16 Feet is older than the 730±40 $^{14}$C yr B.P. date from the A2 horizon at 26.5 Feet, yet from our logging it lies stratigraphically above. We have no simple explanation for the discrepancy.

The trench was temporarily deepened 2 m on the day it was filled in, which revealed a thrust fault dipping up to 55° to the north beneath the crest of the fault scarp. This fault offset the gleyed till beneath the glaciolacustrine stony silts by roughly 0.90 m. In the brief amount of time that the lowermost trench walls stayed intact, we inferred that the sediment at the bottom of the south side of the trench was gleyed till. It was a fine-grained gleyed sediment with larger clasts in it. Alternatively, these sediments may have been the gleyed stony silt found in the hanging wall. If so, there would be continuity of stratigraphy across the fault, and offset on the fault would be greater than we originally inferred—about 1.85 m. The subhorizontal liquefaction features updip of the fault trace accommodated shortening as the fault flattened updip. Some tabular liquefaction features south of the fault dipped slightly south, suggesting that some gravitational sliding occurred in association with near-surface deformation.