Accuracy checks and evaluation of errors in the Silver Cup planetable survey

The surveying involved in mapping this area was checked as it was being done and afterwards in the following ways:

1. All main course shots, i.e. those involved in traverse closures, as opposed to side shots from points in a closed traverse, were checked by reading rod intervals and vertical angles on backsights as well as on foresights. This gave a check on all the more important horizontal distances and changes of elevation as the survey proceeded. In other words all columns of the plane table notes were checked before the survey was continued except the elevation column, and this could include only mistakes in addition of the changes of elevation. Such mistakes, if they occur, can easily be removed later without necessitating any repetition of surveying.

2. The plane table was oriented arbitrarily at the first set up and thereafter by backsighting a previous course. The compass needle was not used to orient the table. However compass north lines were plotted at several points. These may be used in either of two ways:

   (a) Assuming that the compass north lines anywhere within this limited area (approx 1000' x 4600') should be parallel, any divergence of the compass north lines as plotted at these points would give a measure of the accumulated angular error that was introduced between them.

   or (b) Assuming that the foresight – backsight procedure used effectively eliminated any source of angular error in orientation of the table, (such as might be expected to arise from any local attraction if the table were instead oriented by means of the compass needle), and using the plotted compass north lines in conjunction with the known topographic survey coordinates of Alpha, Barbara and Caribou, the difference between true north (astronomical) and compass north, in this area can be determined

Accuracy checks and evaluation of errors in the Silver Cup plane-table survey

3. The available topographic survey stations (Alpha, Barbara, Caribou and Nettie L.) were used to as much advantage as was possible. The survey was extended to include Alpha. ~~This~~ This was meant to give a known elevation from which the elevation of all other points could be calculated and a tie in to the topographic survey coordinates, but the extension to Alpha includes one very long and steep shot which is not known to be reliable. However, direction lines to Barbara, Caribou and Nettie L. were plotted at several points, and the vertical angles to these topographic survey stations were also recorded at some of these points. A complete plot of the survey including these lines and their intercepts, on any convenient scale, can be matched to a plot of Alpha, Barbara and Caribou on topographic coordinates to the same scale, to give a composite from which the horizontal distance from any of these points to the appropriate topographic station can be measured. This horizontal distance, plus the corresponding vertical angle at any point, provides an independent means of determining the elevation of that point. Assuming this plot does not introduce further error in itself, the coincidence or lack of coincidence of these direction lines and the plotted positions of Barbara and Caribou ~~gives~~ gave — because this was given a measure of the accumulated angular error in the various parts of the survey. (The procedure suggested in 2(b), above, was carried out on such a composite plot.)

4. Closed traverses were incorporated in the survey.
.. Even though the table is oriented correctly by backsighting there is a possibility that ~~the~~ it may be shifted by some unobserved movement before the next main course is shot and an accidental error so introduced. Such an error would be discovered in a traverse closure. This survey was closed in the conventional way at three points (at G28, at Q3, and G96). These indicated that a satisfactory accuracy was being obtained so it was not considered necessary to break the survey down into any further sub-closures to localize errors. Two of the three closures indicated that the survey was directionally correct; the closure errors at these points was of a strictly linear nature. The third, (actually the second in the

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rider of our surveying, i.e. the closure at O3), was found to have both an angular and a linear component. However the total closure error at this point was considered within allowable limits so no resurveying was called for.

This survey does not include any adjusted closures. It was not found necessary to adjust any courses to bring closures to the required accuracy, and such adjustment was objected to in principle, because it involves assumptions that are perhaps as often invalid as they are valid.

The lower portion of the survey, from 700 portal to Towser Tunnel, was not closed in the conventional sense but the centre line of the tramline down this part of the hill was plotted wherever it crossed the switchback road and these points were found to lie on a straight line. As either an angular error or a linear error would have caused these centre-line points to plot differently this line can probably be considered a legitimate closure.

5. Some further independent checking was provided as an incidental part of a compass and tape pickup of geology by Hans Trettin and Doug Irving.

6. A rough check of the elevations in this survey ~~was~~ can be obtained from two barometer traverses from Silver Cup cabin to Alpha. These were done on August 8th and August 10th/56 using barometer #D-786. This barometer will duplicate readings to within 10 ft.

Difference between true (astronomical) north and compass north
at Silver Cup mine   July 22 - Aug 18, 1956.
(using the procedure discussed in 2b + 3 of "accuracy checks & evaluation of errors")

Declination at   from

Δ1 = 23°50' } plane table sheet #1
Δ12 = 22°15'

Δ31 = 21°20'   "   "   #2 — course ⊙2 to Δ9 as base
Δ31 = 22°   "   "   #2 — course ⊙2 to Δ31 as base

Δ35 = 21°   } plane table sheet #3
Δ47 = 21½°

Δ55 = 22°   } plane table sheet #4
Δ56 = 22°
Δ12 = 21½°

665 = 21½°   } plane table sheet #5 — A part
Δ14 = 21½°   B part

Δ60 = 21° — plane table sheet #6

total = 12

average of all, less the most divergent determinations (21°, 21° + 23°50')
= 195°35' ÷ 9 =   21°44'

average of all shots including the divergent ones
= 261°25' ÷ 12 =   21°47

(right side calculations)

23 50
22 15
46 05
21 20
67 25
66   (3×22)
133 25
42   2×21
175 25
86   4×21½
261 25

3×22 = 66
4×21½ = 86
        152

22 15
21 20
43 35
195 35

(bottom left division)
        21° 44'
    9 | 195° 35
       18
       15
        9
        6 —— 360'
                 35'
            9 | 395
                36
                35
                36

(bottom right division)
        21° 47'
   12 | 261 25
        24
        21
        12
         9° —— 540'
                  25'
           12 | 565
                48
                85
                84

Accumulated angular error as indicated by lack of coincidence of direction lines to topographic survey stations and the plotted positions of the topographic stations Alpha, Barbara and Caribou.

These figures were obtained from a composite (1"=1000' scale) plot produced by transferring direction lines from the plane table sheets to the smaller scale drawing and fitting to this a separate plot of Alpha, Barbara & Caribou.

direction line	fails to coincide by	approximate angle represented	
Δ3 – Barbara	fits exactly	nil	
✓ – Caribou	40ft (North) in 6900'	1/3° (20')	
Δ9 – Caribou	30ft (South) in 6900'	1/4° (15'+)	
Δ10 – Barbara	fits exactly (4500' to Barbara)	nil	
✓ – Caribou	25ft (South) in 7160'	(12'+)	accumulated angular error plane table sheet #1
Δ12 – Caribou approximation – ran 20'N (Caribou 7530'away)		(10'−)	
Δ58 – ✓	15–20' in 7760	(10'−)	
Δ15 – ✓	5' N (essentially exact) Caribou 7670'away	(2.4')	
Δ15 – Barbara	exact (4930')		
Δ15 – Nellie L	—— no check	—?	
Δ23 – Caribou	exact (6900')	nil	

These points are all on plane table sheet #1. They were plotted on reduced scale by putting α on the 1"=1000' tracing coincident with α on the 1"=100' plane table sheet. Then lines from α to all stations on plane table sheet #1 were a common direction to both the 1"=100' & the 1"=1000' plot. Distances in these directions were plotted at the smaller scale on the tracing. ⊙2 was one point replotted in this way. This point on the 1000 scale sheet was then put coincident with ⊙2 of plane table sheets #2 & #3 to get other direction lines. This one point coincidence gave a hub from which rays could be drawn to pick up other points but in addition one course had to be coincident on the 1000' scale plot and the plane table sheet to which it was transferred. On the reduced scale this was a less reliable base line for further plotting. Also due to the reduction of scale the error introduced by plotting error was ten times greater, relatively, when it was equal in absolute measure. These two factors probably account for most of the increase in accumulated angular error suggested by the following figures.

direction line	fails to coincide by	approx. angle represented
Δ32—Caribou (sheet 2)	200' (south) in 6660	approx 2° (1°50')

If this represents an angular error on the plane table sheet it would be necessary to rotate Δ32—Caribou clockwise to correct it. If sheet 2 is then reoriented on the base compass N at Δ31 would be increased by this amount (to 21°20' + 1°50' = 23°10' from true north) It seems probable that most of this angular error is in the ~~1000~~ 1"=1000' composite rather than in the 1"=100' plane table original.

Δ38— Caribou (sheet 3)	60' (South) in 6200'+	6/10° (36')
Δ47— Caribou (")	100' (South) in 6050'	1°
Δ47— Barbara (")	70' (east) in 4875' ————	(51')
Δ51— Caribou (")	110' (south) in 6250' ————	1°+
Δ53— Caribou (")	175' (south) in 6150' ————	1 3/4°

Three more direction lines were plotted on sheet 1 from α₁, a set up 4 ft from the ~~sur~~ cabin on Alpha. These did not check nearly as well as the other plots on sheet 1.

α₁ — Barbara	70' west in 6000'	(42')
" — Caribou	75' N in 8600'	(45'+)
" — Nellie L	no check	—?

If the composite 1"=1000' plot used to arrive at these figures can be considered completely accurate it may be assumed that any warping of a line, or any dislocation of a contact or similar feature, that represents an angular displacement in excess of 2° (1°50') must be attributed to some other cause than accumulated survey error. As the composite is more likely to have errors in it than the original work it is probable that the accumulated angular error anywhere in the survey does not even approach this high a value; (for confirmation see the other checks on the accuracy ~~of this~~ survey).

closure at Δ18-628
length of traverse involved:

		cumulative
Δ10-11	= 177½	
11-12	= 277½	455
12-13	334	789
13-15	268	1057
15-16	414	1471
16-17	365	1836
17-18	250	2086
18-628	130	2216
628-Δ10 =	200'	2416

(error is all linear)

closure error = 9' in 2416' (HD)

= $\frac{9}{2416} \times 100\%$ = approx 0.4%

2416) 900.0   .4
       9664

elevation closure error = 4.1'
on that Δ17-Δ18 → 628
+ 3.8' on that Δ10-628 → Δ18

closure at ⊙3
length of traverse involved

Δ3-Δ2	= 385	
2-10	234	619'
10-11	177½	796½
11-12	277½	1064
12-13	334	1398
13-15	267	1665
15-16	414	2079
16-17	365	2444
17-20	60	2504
20-21	221	2725
21-26	149	2874
26-25	107	2981
25-27	174	3055
27-28	92	3147
28-29	171	3318
29-30	122½	3440½
30-⊙3	150	3590½
Δ9-⊙3	100	3690½
Δ3-4	182	3872½
4-5	162½	4035
5-6	248	4283
6-7	275	4558
7-8	212	4770
8-9	213	4983

horizontal distance total = 4983'
closure error = 12 ft (HD) & 2.6' vertical

relative error = $\frac{12}{4983} \times 100$ = .24%

4983) 1200.0   .24
       9966
       20340
       19932
       408

(error has both linear and angular
components here)

closure at G96   (error is all linear)

(7-10) HD   5.6 vertical
±1

ELEVATIONS BY BAROMETER D-786

Wed Aug 8/56
Silver Cup cabin	935 AM	= 5360'	−153	= 5207
700 portal	1006 AM	= 6370'	−153	= 6117
Δ3 at 400 portal	1018 AM	= 6700'	−153	= 6547
Δ2 at 300 portal	1027 AM	= 6775'	−153	= 6622
G45 at the upper shaft	1033 AM	= 6953'	−153	= 6800
Alpha	1114 AM	= 7800'(7799)	−153 correction	= 7647 the elev. given by topographic survey.
Silver cup cabin	850 PM	= 5360'		

Fri Aug 10/56
Silver cup cabin	853 AM	= 5320'	−123	= 5197'
300 portal	928 AM	= 6740'	−123'	= 6617
Alpha	1006 AM	= 7770'	−123' correction	= 7647'

elevation of Silver Cup cabin by average = 5202' (datum for further
barometer traverses out of Silver Cup camp)

Difference in Elevation from 6/55 and Δ59 : 80'

" " " from Δ15-Δ14 between 100 and 55.5'

average 78'

Difference in Elevation from barometer readings.

True Elevation ∝ 7647

Assumed el.

Δ_2 = No.3 - Adit

6742'   Difference
                         7.6 47
                         6 7 4 2
                         ‾‾‾‾‾
                           9 0 5

Assumed El.

Δ_3 = No. 4 Adit

6648'

                         7 6.4 7
                         6 6 4 8
                         ‾‾‾‾‾
                           9 9 9

Reading at Δ2		at ∝ Ready	Difference	Correction
6700		7800	1100 / ~~~~	~~~~ 101
at Δ2				
6775		7800	~~~~ / 1025	120'
Reading				
Δ2 : 6740		~~~~ / 7770	~~~~ / 1030	125'