A brief examination of ground models of Silbury Hill

1. Background

The aim of this report is to examine potential evidence for movement of Silbury Hill based on two surveys separated by 33 years. The models come from two very different data sets – an aerial photography survey of 1968 and a GPS survey of 2001. The sources mean that there will be some differences between the models that are due to the survey control employed, and due to the plotting techniques. Thus, perfect correspondence could not be expected even if there was no movement. The Photogrammetric Unit plotted the 1968 photos based on the survey control data that was preserved along with the photos, and a contour plot (figure 1) was circulated along with some rendered isometric views. The GPS model comes from the Archaeological Survey team in Swindon (fig 2). The following analysis was performed using AutoCAD R14 and Key Terra Firma, based on models generated from the supplied survey data.

2. Initial results

When compared, it is clear that the 2001 survey has the top of the hill at approximately 186.5m OD, while the 1968 survey has it at approximately 187m OD. When the two models are examined for points where they intersect one another, this seems to happen only along the south side (see fig 3). Further, volumetric comparisons show a deficit of 16,712 cubic metres between the models (17,816m3 to cut from the '68 surface compared to 1,104m3 to fill) spread over 22,030 square metres of the 23,633 square metres of compared surface. This could represent wholesale shrinkage of the monument in the intervening 33 years, and the high points could be where the south slope has been stabilised as evidenced by the recent discovery of buried wire mesh near the summit. However, careful comparison of the models suggests that while the south slope might be unchanged, the north side has shrunk back by two and a half metres at its base, and the sides have shrunk back by smaller amounts. This asymmetrical shrinkage seems odd, and if the survey control from both surveys is accepted as being adequate then there is a complex movement issue to address.

3. Factors affecting the models

However, the control frameworks for the two surveys cannot be equated exactly, and indeed the 1968 framework may not even be completely recoverable as most of the markers seem to have been temporary crosses for the photos, with only a few points on less temporary objects such as fence posts and a telegraph pole. Not only will the 1968 survey have potential errors due to the nature of traversing with theodolites and levels from nerarby trig pillars, but also the OSGB36 grid coordinates for the trig pillars from which the survey will have started no longer match the revised OS grid as agreed in 1997. GPS is a far more exact survey method over long distances, and it has forced a revision to the way in which the Ordnance Survey national grid is adjusted by highlighting the areas where errors exist in the 1936 grid. Added to this, the markers in the photos will be subject to the maximum precision offered by the grain size of the photographs, and will not have the same accuracy as the GPS data points, which are accurate to a centimetre or so in the horizontal and two centimetres in the vertical plane. Finally, the topographic points on the AP had to be adjusted down in height to account for the likely height of the grass on the hill, adding a small uncertainty to the 1968 model.

4. Revised comparisons

If the control comparison might be suspect, then it stands to reason that the models could be "shifted" to achieve better alignment. The one element of each survey that can be relied on is the relative consistency between topographic data points within each model, even if the location of each of these "data clouds" on the OS grid is uncertain. As the surface area of the summit in each model seemed the same, corrections were determined to bring the summits into alignment so changes in the sides could be examined. Halving the north/south difference in model dimensions gives a displacement of 1.2m, while the height difference is approximately 0.7m. Figure 4 shows the revised comparison of intersection when the 2001 model is moved north by 1.2m and moved upwards by 0.7m to align with the 1968 survey. The result is a surprisingly high degree of overlap as seen in the intersection lines, and this overlap is distributed over much of the modelled surface. The resulting calculations show a volumetric growth of only 984 cubic metres (2520 cut and 3504 fill), with the areas covered being almost evenly distributed at 14,112 square metres of cut and 9,625 of fill. Much of this change appears associated with the lower slopes of the south side, where post-1968 tunnel infill and landscaping may well have altered the surface model. Figure 5 shows the 5-metre contour lines of the "adjusted" models superimposed, and again there is a close correspondence. If the arbitrary method by which the 2001 data were adjusted can be accepted, the results are a model that shows little if any major movement of the hill. There are no significant pockets of wholesale change, as might be expected if tunnel collapses had altered the shape of the mound. Unfortunately, the models do not include the recent void at the top (for obvious health and safety reasons), so there can be no examination of the only confirmed change in the shape of the mound.

5. Conclusions

If the unadjusted data are used, then the mound has moved over the years, but in a strictly uniform way. If, however, the data are accepted as adjusted, then there appears to be no discernible change in the monument.

6. Limitations to the comparison

The 1968 model is plotted to include some of the surrounding landscape, while the 2001 survey was restricted to the monument within the fence at the base of the hill. The comparison was therefore based only on the mound and the southern apron, and lacked the extra baseline data that the surrounding landscape could have provided. The exercise should be repeated once the GPS survey has been extended to these areas. Also, if the control framework is to be narrowed down for more accurate comparison it will be necessary to attempt to find what few fixed points existed from the 1968 survey in order to capture them on the 2001 grid. This is especially true if new aerial photogrammetry is to be taken.

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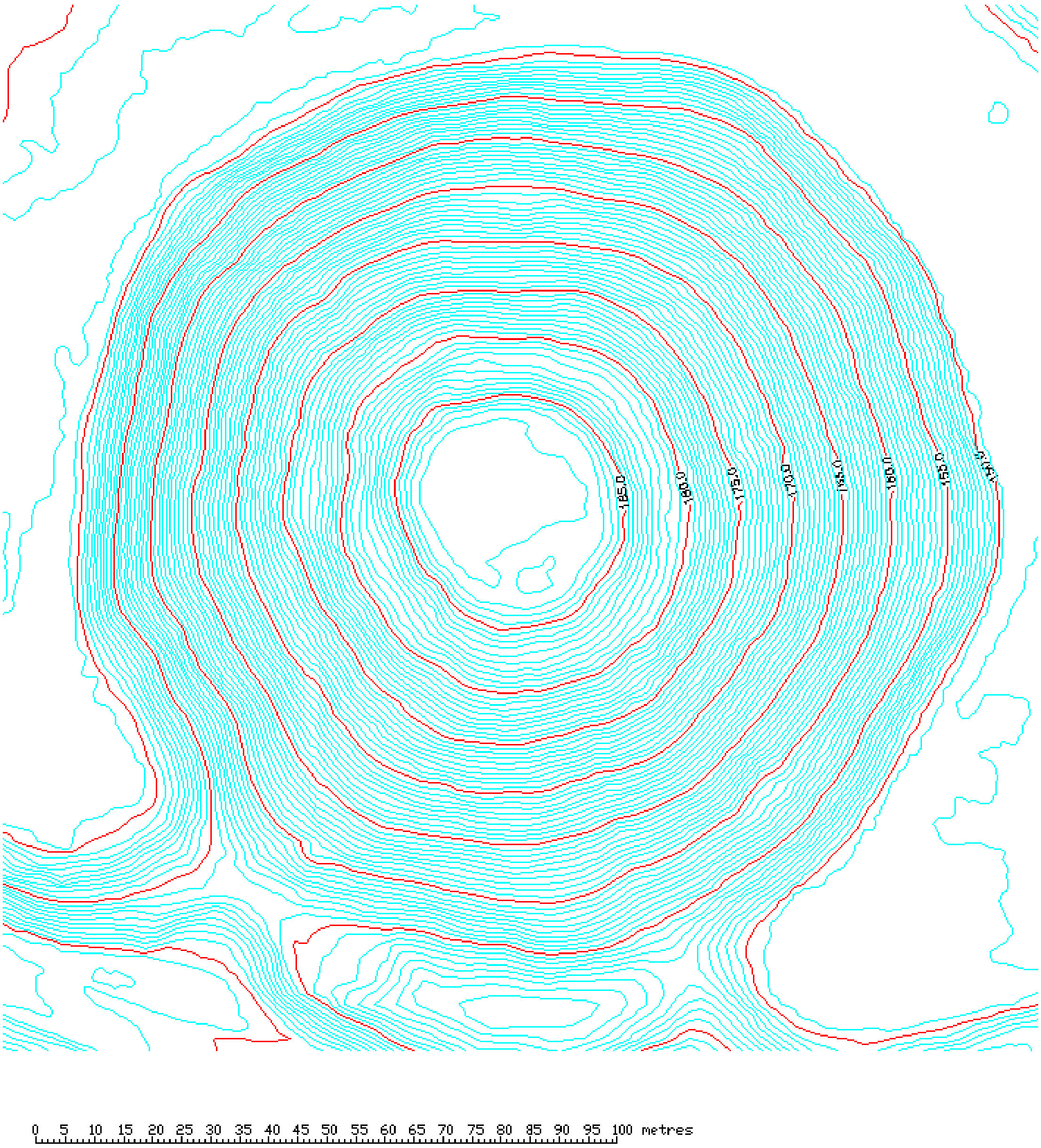

Fig 1. Half-metre contour plot of 1968 survey, with highlights at 5m intervals.

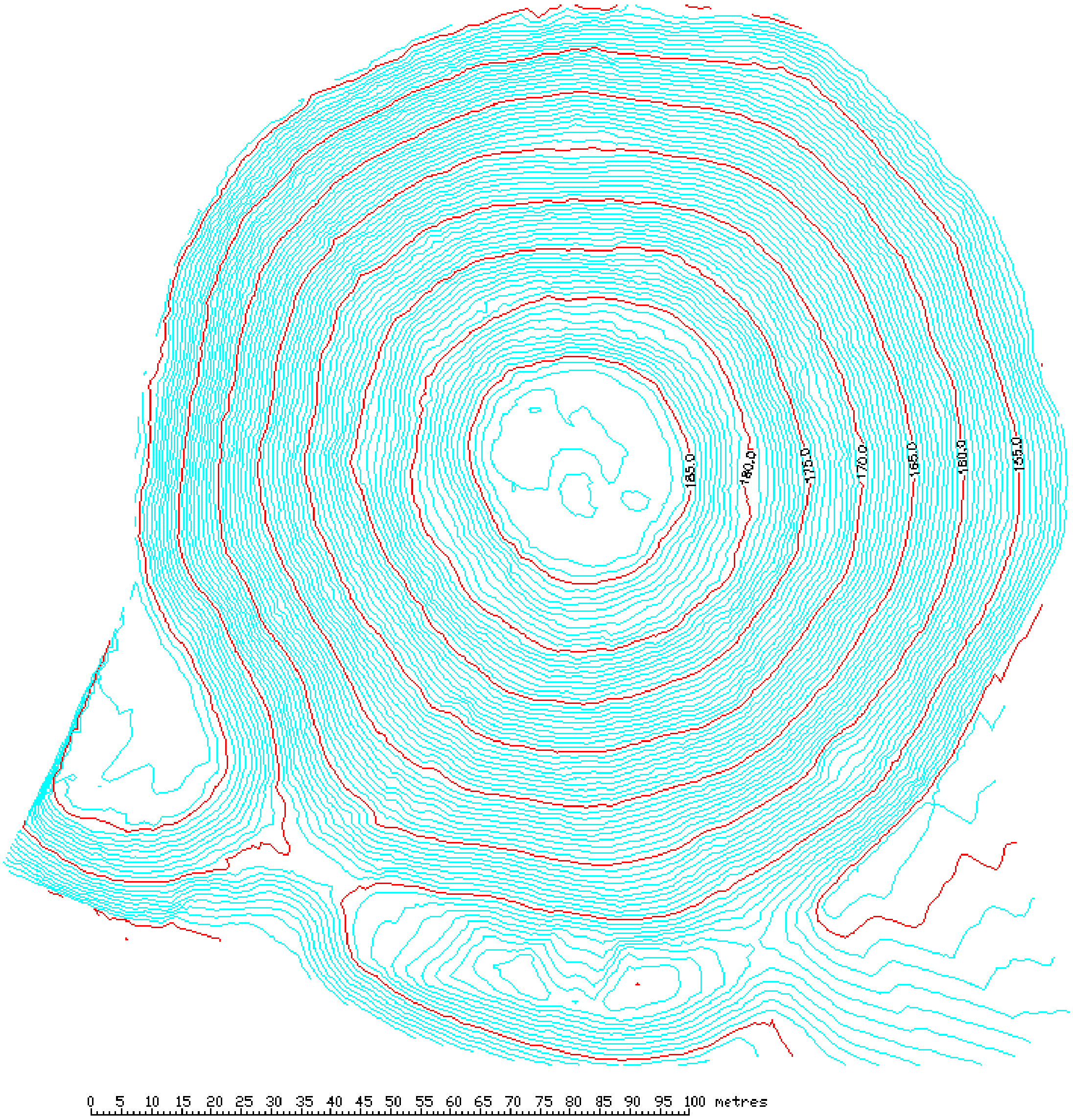

Fig 2. Half-metre contours from unadjusted 2001 GPS survey, with 5-metre contours highlighted. Note overall difference in height of the hill compared with Fig 1.

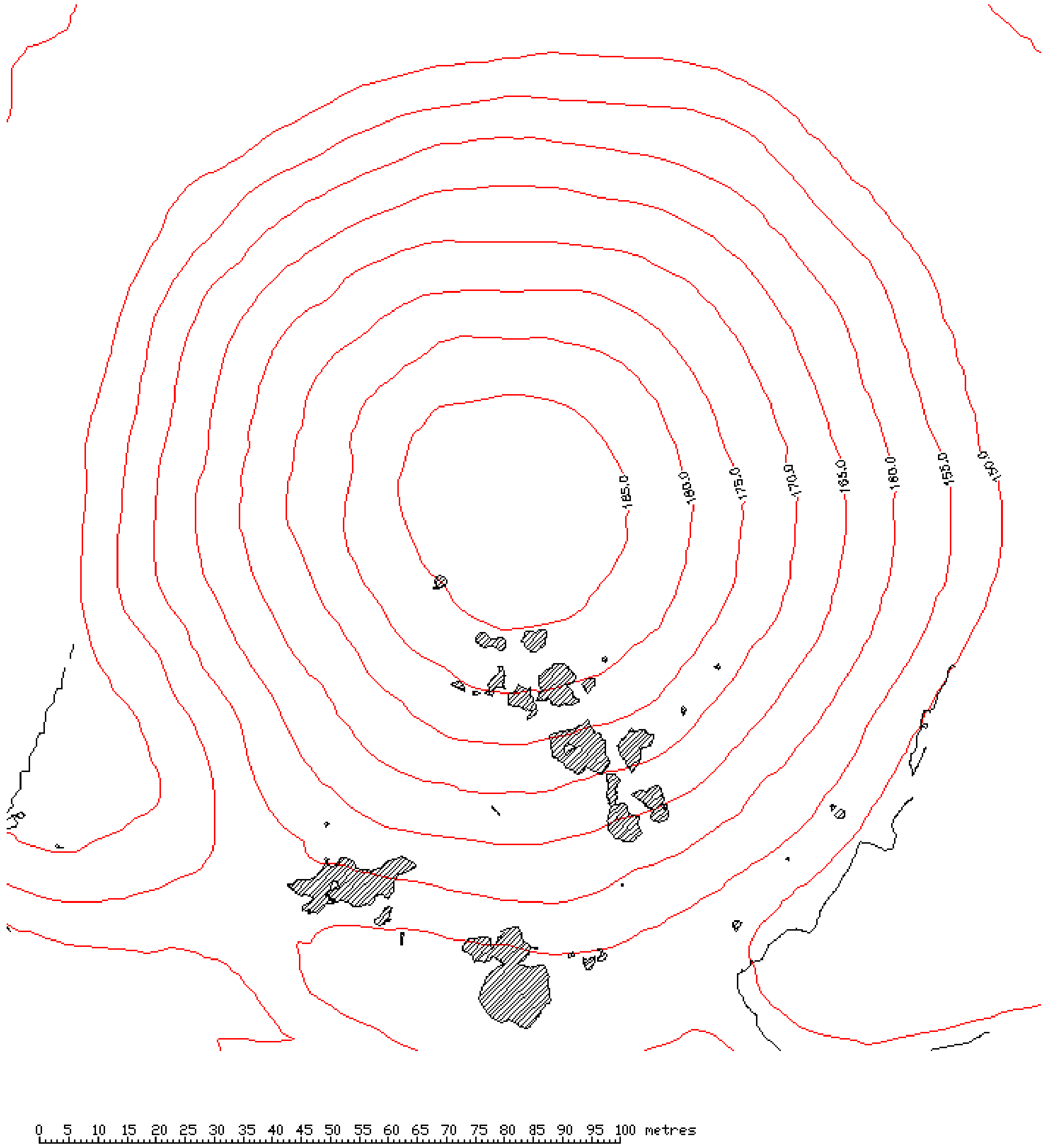

Fig 3. Intersection areas (shaded) of 1968 and 2001 unadjusted models, plotted over 5-metre contours from 1968 survey. Note that models touch only on south side.

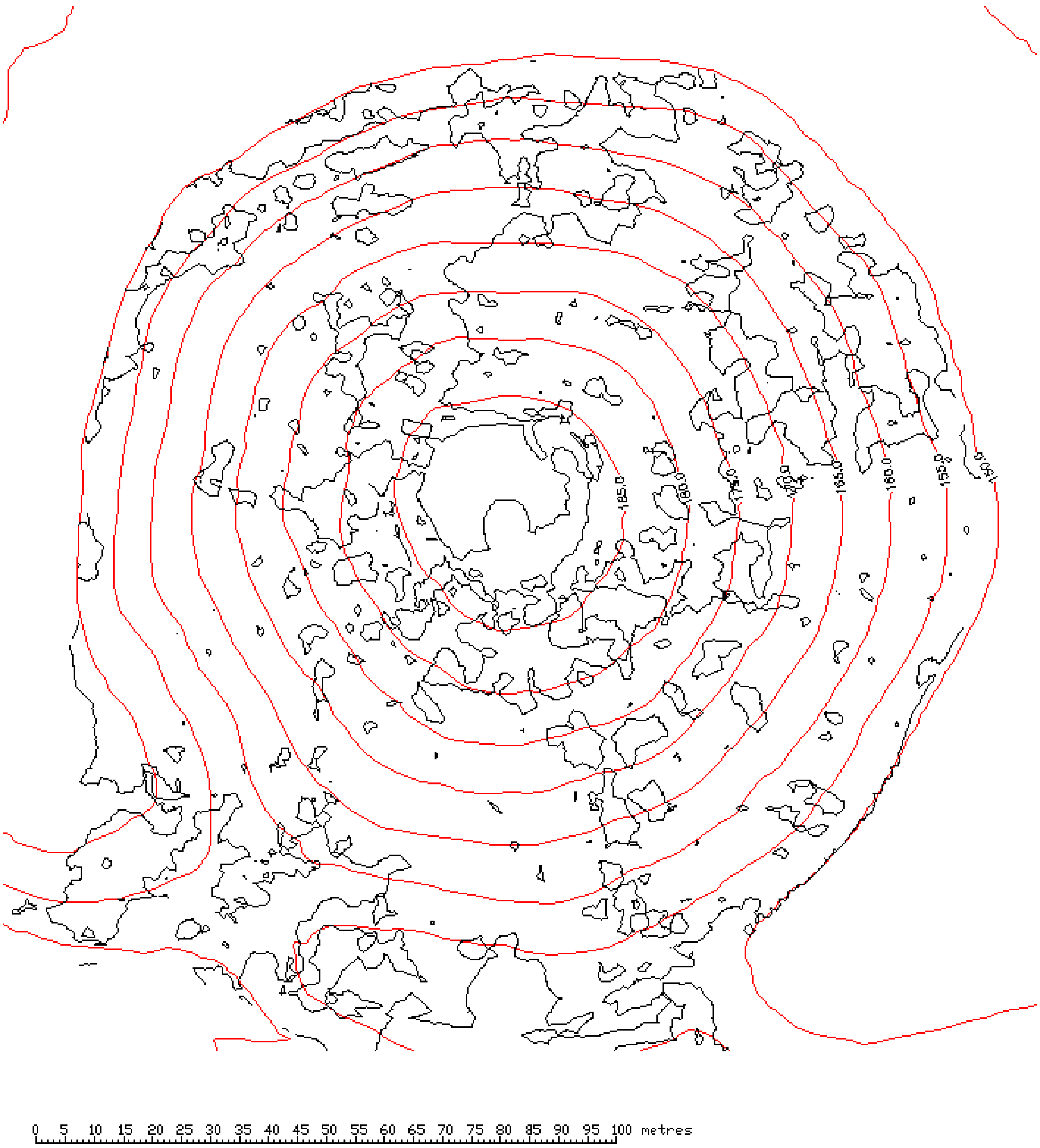

Fig 4. Intersection lines from "adjusted" models. Note fairly even coverage. Lines represent areas where heights are exactly the same, so areas with height differences of only a few centimetres will not be marked.

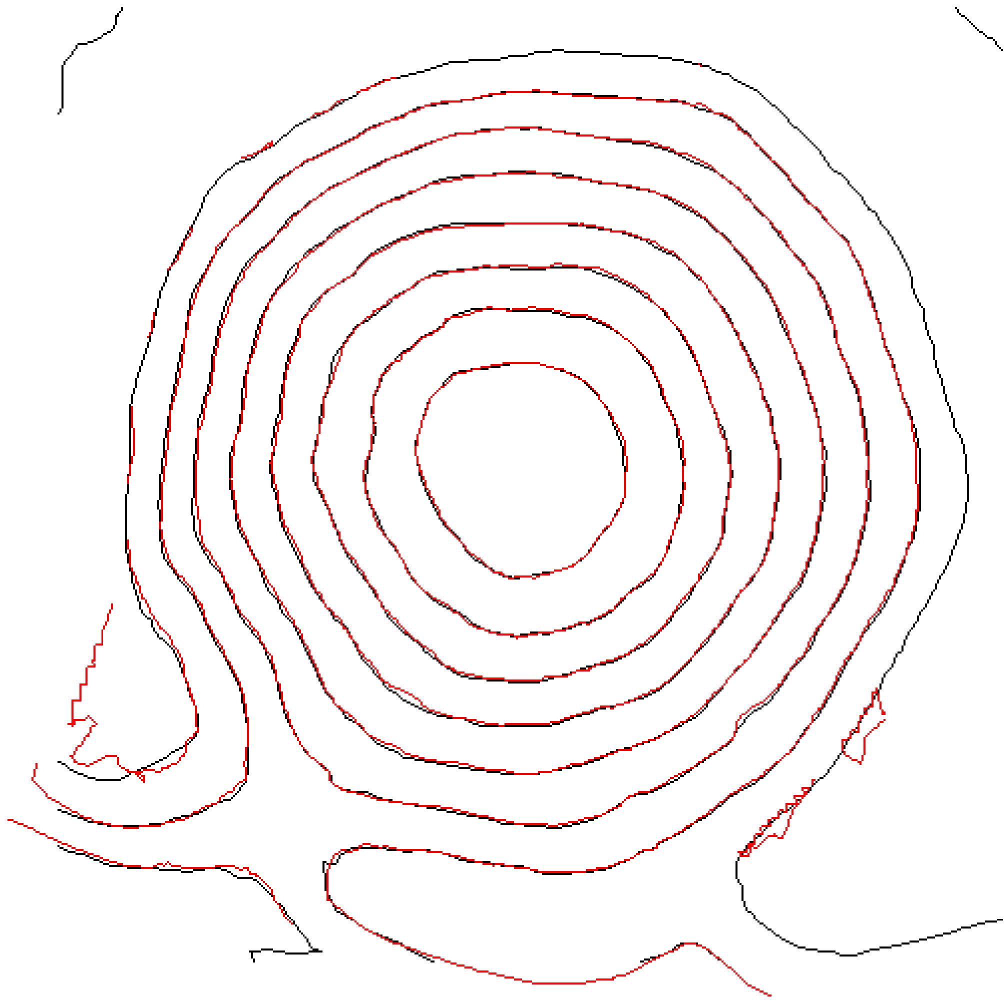

Fig 5. Contour comparison between 1968 and “adjusted” 2001 surveys at 5-metre intervals. Note close correspondence between models except around base.