Rerum Naturalium Fragmenta

No. 462

Watford
2006

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Rerum Naturalium Fragmenta
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Paramount peaks and summit level of Scotland determined from DEM data

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Abstract
Digital elevation model data (SRTM3) were used as a preliminary scan of local maxima to find summits (peaks) in Scotland and adjacent areas. The maxima were checked to find paramount peaks by eliminating all peaks visible from higher peaks. Pair-wise inter-visibility was computed by formulae for theoretical planetary visibility excluding atmospheric effects.

The set of candidate summits (presumed paramount peaks) was refined by comparison of published elevation data to obtain precise spot height values instead of the pixel averages.

The procedure found 37 paramount peaks in the whole of Scotland. If we exclude the summits of Rockall, Fair Isle and Shetland, altogether 7 summits, the remaining 30 form a compact group representing the mainland, the Western Isles and Orkney. This smaller set was used for further analysis, with the addition of The Cheviot.

Comparing the set of paramount peaks to the official list of Munros we find that while the lists share the highest summits, there are marked differences. The differences are explained by the criteria of selection. Munros are defined by the (somewhat arbitrary) cut-off height of 3000 ft, while our selection is more flexible and less arbitrary.

Nearest neighbour spanning trees were computed for the set of 31 paramount peaks. Similar trees were computed for other data sets of random data and actual data (summits of other areas) to compare

statistical parameters: counting the number of branching points and chain segments in the graph edges.

When we contour the surface defined by the paramount peaks for mainland Scotland we get a smooth surface, an objectively defined summit level, or gipfelflur. The surface is not a perfect plane, but gently sloping away from the centre in every direction, as expected from an ancient erosion surface. The summit level is so smooth that it is hardly dented even by such major valleys as the Midland Valley and the Great Glen. This, and the fact that the paramount peaks consist mostly of pre-Carboniferous rocks, indicates an early age for the summit level.

Definition of paramount peaks

A peak is dominated by another (higher) peak if

$$d^2 < h * R$$

where

h – the difference of height

d – the distance between the peaks

R – the radius of the earth.

If heights are measured in meters and distances in kilometres, then R = 6.36 (for precise calculations, the actual value depends on the latitude of the area).

The formula is derived from the theoretical planetary visibility formula (Adam 2003, Close & Cox 1913)

$$d = \sqrt{hR}$$

taking into consideration the curvature of the Earth but ignoring atmospheric effects.

For an analysis of errors see Close & Cox 1913. Adam gives tables of values for heights in feet and distances in miles.

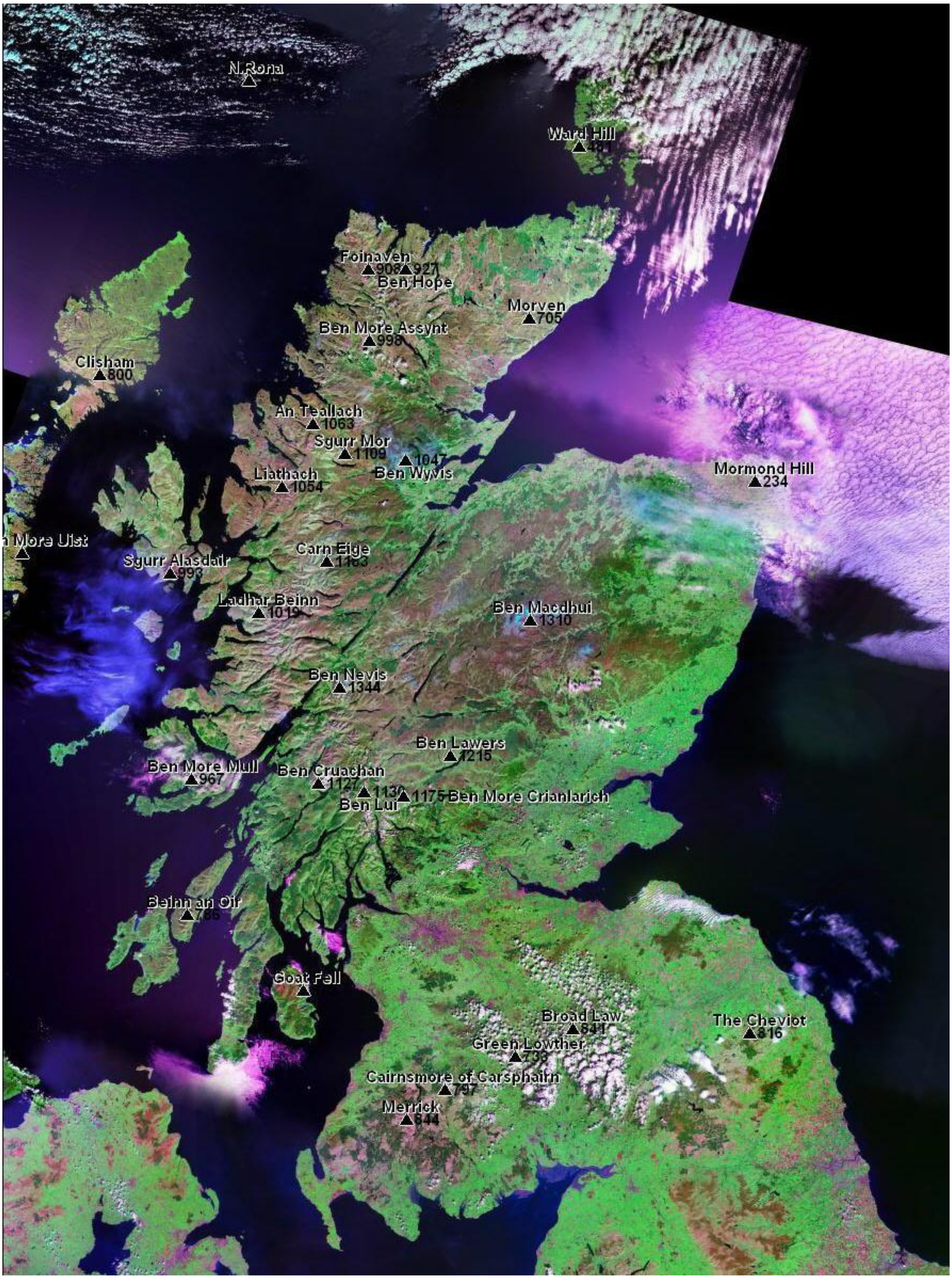

Figure 1. Paramount peaks of Scotland. Visible UTM map

Paramount peaks are defined as peaks that are not dominated by any higher peaks.

In simple terms, an observer on a paramount peak will not see a higher peak.

To determine if a peak is paramount, it needs to be checked against the candidate list of higher peaks that could possibly dominate it, within a distance of about 100 km.

In practice, a set of peaks can be gradually reduced in stages by checking first against the highest peaks in the immediate neighbourhood and eliminating those peaks that are dominated by others; then proceeding for a wider sweep check of the remaining candidates. In some cases the accuracy of the input data may not be sufficient to allow a clear-cut decision and requires a further stage, a repeat run with increased precision.

Data sources

Digital elevation data of SRTM (NASA Shuttle Radar Topography Mission) cover the whole Earth. Datasets are in 2 resolutions: 3-second and 30-second, each is arranged in a simple array; so the projection is a kind of pseudo-Mercator. These data can be downloaded from the SRTM website.

Visible UTM mosaic (Landsat 1990/2000 processed data) images are combined from multiple spectral channels, enhanced to show land use etc. with extra contrast and transformed to UTM. As far as possible, clouds are removed from land areas, less so over sea. The Earth between 60S and 60N is covered by images of 6 * 5 degrees with some overlap, between 60N and 80N the coverage is about 12 * 5.

Processing of data

SRTM3 digital elevation model data (NASA 3 arc second radar altimetry) were used as a preliminary scan of local maxima to find summits (peaks) in Scotland and adjacent areas. The almost complete uniform coverage made these data ideal for a first general sweep to locate candidate peaks. The data are mean values of readings obtained in the 3*3 arc second area, typically 60 * 100 m. This permits the precise location of summits, but not their height. Because the maps list the height of the highest spot defined on a much smaller area, SRTM peak heights will be less than "true" spot heights by up to 50 m in extreme cases.

Local maxima (peaks) were extracted and listed with x, y, z values for a preliminary round of elimination, with a threshold value set to avoid misclassification caused by the uncertainty of peak heights and positions.

The reduced set of peaks was then checked against published data to refine and make heights more precise, and. Also, summits were added from topographic maps where there were gaps in the SRTM3 data coverage. Then the computation was repeated to arrive at a final classification of peaks.

Comparison of published data occasionally revealed interesting discrepancies. As an extreme example the position of Rockall is given as 57.45N 14.00W by the Encyclopaedia Britannica, as 57.40N 13.30W by the Times Atlas and as 57.36N 13.41W by Wikipedia. Its height is given as 19 m by BBC/H2G2 and as 22 m by Wikipedia. The small dimensions of Rockall are also confusing the identification in the SRTM data. Despite the uncertainty, its large distance from land makes it doubtless a paramount peak.

Paramount peaks of Scotland

The scanning and elimination procedure found 37 paramount peaks in the whole of Scotland. These are listed in Table 1. While strictly speaking not a Scottish peak, being just inside England, The Cheviot, was added to the table, and used in further analysis. Thus the table contains 38 paramount peaks.

From these a compact group was selected for geometrical analysis. The 31 paramount peaks include the paramount peaks of the mainland, the Hebrides and Orkney, and in addition, The Cheviot, but exclude the summits of Rockall, Fair Isle and Shetland, outlying summits.

Fig. 1 shows the paramount peaks of this group plotted on a background of NASA visible spectrum mosaic map. The image is a composite of two NASA maps in the same UTM zone covering the mainland of Scotland and part of the Hebrides.

Fig. 2 is a shaded relief map of the same area; the relief is computed from SRTM data and is overlain on the visible spectrum images.

Table 1

The paramount peaks of Scotland

No.	Peak	Class	Height	Latitude	Longitude	DEMh	hdiff	Dlat
1	Ben Nevis	MM*	1344	56.48N	5.00W	1335	9	56.796
2	Ben Macdhui	MM*	1310	57.04N	3.40W	1308	2	57.069
3	Ben Lawers	MM*	1215	56.33N	4.13W	1194	21	56.544
4	Carn Eige	MM*	1183	57.17N	5.07W	1170	13	57.279
5	Ben More (Crianlarich)	MM*	1175	56.23N	4.32W	1156	19	56.386
6	Ben Lui	MM*	1130	56.24N	4.49W	1110	20	56.397
7	Ben Cruachan	MM*	1127	56.26N	**5.09W**	1091	36	56.426
8	Sgurr Mor	MM*	1109	57.42N	5.01W	1089	20	57.699
9	An Teallach	MM*	1063	57.48N	5.15W	1028	35	57.807
10	Liathach	MM*	1054	57.34N	5.28W	1029	25	57.563
11	Ben Wyvis	MM*	1047	57.41N	4.35W	1041	6	57.678
12	Ladhar Beinn	MM*	1019	57.04N	5.35W	993	26	57.074
13	Ben More Assynt	MM*	998	58.08N	4.52W	984	14	58.137
14	Sgurr Alasdair	MM*	993	57.13N	**6.14W**	951	42	57.212
15	Ben More (Mull)	MM*	967	56.25N	6.01W	953	14	56.424
16	Ben Hope	MM*	927	58.25N	4.37W	920	7	58.413
17	Foinaven	M*	908	58.25N	4.53W	895	13	58.411
18	Goat Fell	M*	875	55.38N	5.12W	852	23	55.625
19	Merrick	M*	844	55.08N	4.28W	837	7	55.138
20	Broad Law	M*	841	55.30N	3.21W	839	2	55.498
	The Cheviot	*	816	55.29N	2.09W	816	0	55.477
21	Clisham	M*	800	57.58N	6.49W	787	13	57.962
22	Cairnsmore of Carsphairn	M*	797	55.15N	4.13W	793	4	55.256
23	Beinn an Oir	M*	786	55.54N	6.00W	757	29	55.903
24	Green Lowther	M*	733	55.23N	3.44W	733	0	55.389
25	Morven	M*	705	58.14N	3.42W	681	24	58.233
26	Beinn More S.Uist	M*	610	57.15N	7.18W	600	10	57.258
27	Ward Hill [Orkney]	M*	481	58.54N	3.20W	477	4	58.899
28	Ronas Hill	M	450	60.32N	1.26W			60.530
29	Conachair [St. Kilda]	M*	430	57.49N	8.34W	409	21	57.820
30	The Sneug [Foula]	M	419	60.08N	2.06W	409	10	60.139
31	Royl Field [Shetland]	M	293	60.02N	1.17W	292	1	60.038
32	Saxa Vord	M	285	60.50N	0.50W			60.830
33	The Ords [Shetland]		284	59.54N	1.23W	280	4	59.905
34	Mormond Hill	*	234	57.36N	2.04W	234	0	57.604
35	Fair Isle		217	59.33N	1.38W	203	14	59.545
36	N.Rona	*	101	59.07N	5.49W	96	5	59.120
37	Rockall		22	**57.35N**	**13.41W**	3	19	57.578
							14	

Notes:
1. The Cheviot, England, was included in the geomorphological analysis
2. The height and position of Rockall is given differently by different authorities
3. Class: MM = both Munro & Marilyn, M = Marylin, * = selected for analysis
4. Bold figures indicate values differing more than a minute (lat/long) from published sources

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Applications of paramount peaks

Paramount peaks present an interest both for further study and practical applications.

These include mountaineering, geomorphology and such practical problems as the location of transmitters and observation points.

Comparison to Munros, and other classes of peaks

There are a number of classification schemes for peaks used by mountaineers. The oldest, best known, and perhaps most widely used is the list of Scottish peaks of 3000 ft compiled by Hugh Munro, the "Munros". The scheme, with variations, was extended to other countries and continents and a number of further classes of peaks was compiled during the 20th century, among them the lists of "Marilyns".

The list of paramount peaks in Table 1 shows whether the paramount peak is also a Munro and a Marylin. As expected, every paramount peak over 3000 ft is a Munro, they are also Marylins. There are a number of lower paramount peaks which are Marylins, and finally some paramount peaks which are neither Munros nor Marylins. On the other hand, there are hundreds of Munros (and Marilyns) that are not paramount peaks. Altogether paramount peaks are a more select and perhaps more "natural" class.

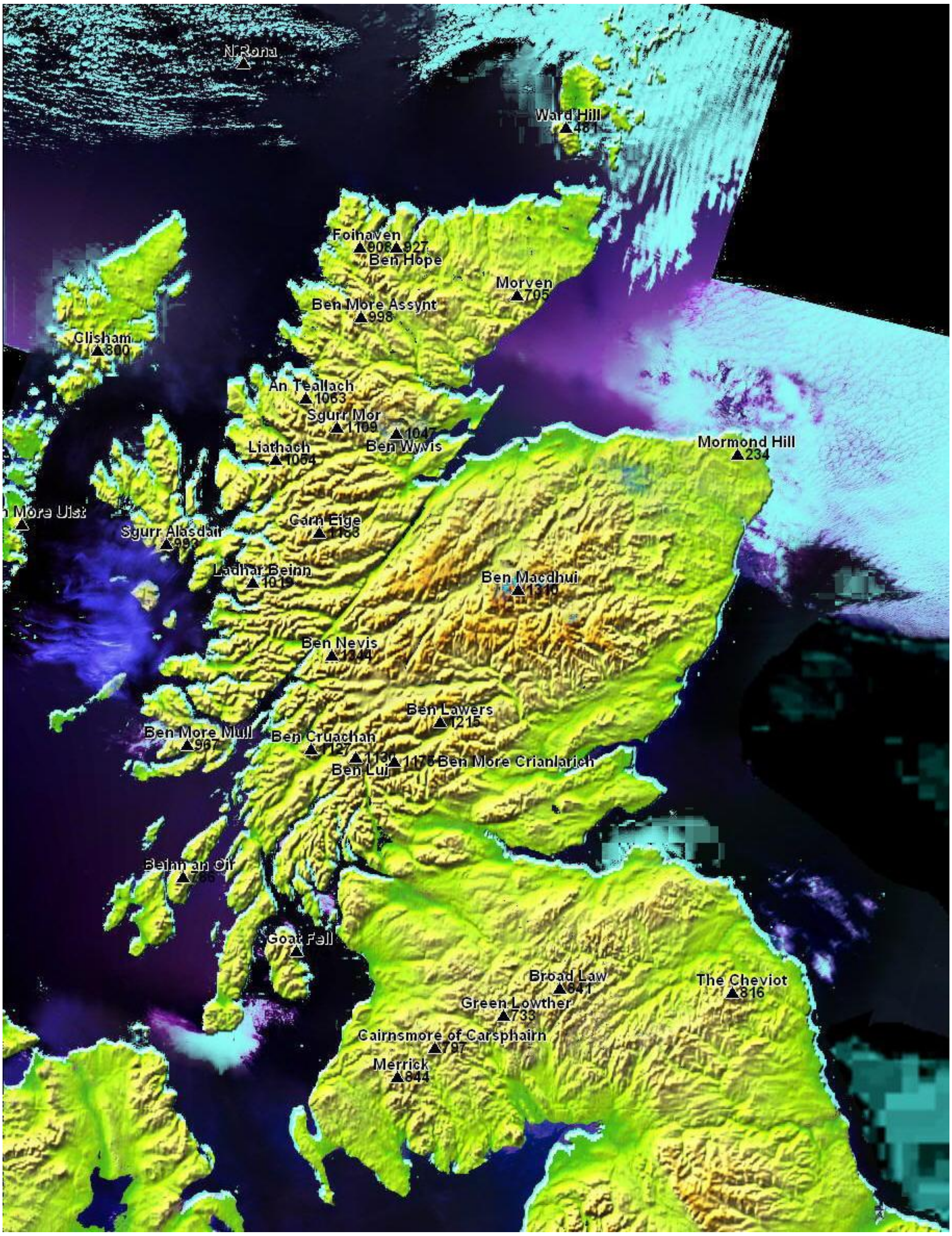

Figure 2. Paramount peaks of Scotland. SRTM elevation map

Nearest neighbour trees

Nearest neighbour spanning trees were computed for the selected set of 31 paramount peaks. In the first step the algorithm connects each point to its nearest neighbour.

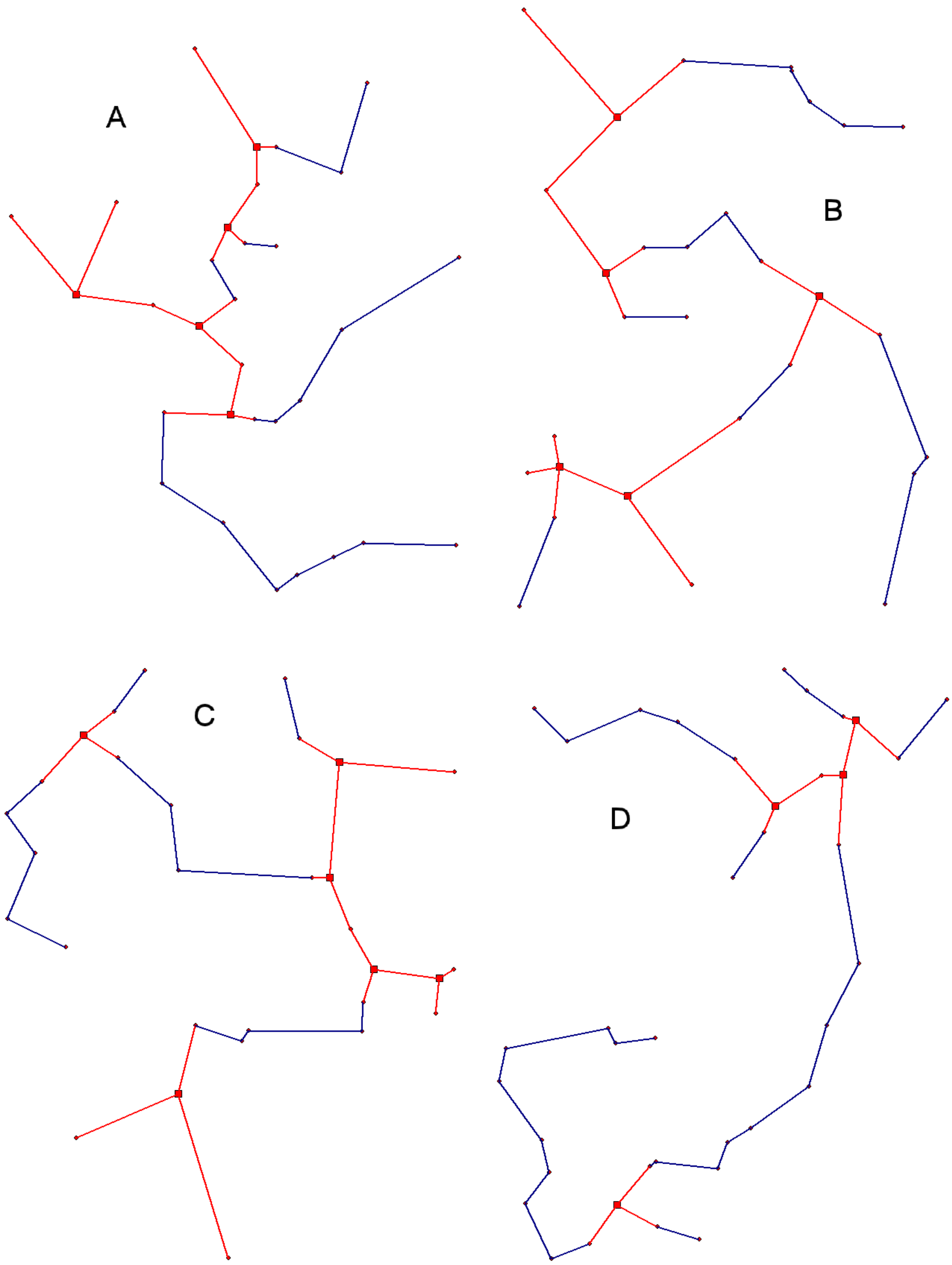

Figure 3. Nearest neighbour trees

After the first stage a check is made whether all points are connected; if there are several disconnected (partial) trees, then the program finds the two groups that are separated by the shortest distance and merges them by making the (shortest) connection. This step is iterated until the tree connects all points.

The resulting tree graph is shown in Figure 3, A.

Similar trees were computed for a number of random data sets and for summits of other areas. Figure 3, B & C show typical trees of random data while D is the nearest neighbour tree of paramount peaks in an area of fresh Alpine tectonics.

Are these trees similar or different? Counting the number of branching points and chain segments can make statistical comparison of trees. Branching points are the points connected to 3 or more points in the tree. Chain segments are segments (graph edges) whose end points are not branching points i.e. both end points have 2 or less connections. In Fig. 3 branching points are highlighted by red squares, chain segments are drawn in blue.

The expected value and standard deviation can be established empirically for both parameters by Monte-Carlo simulation.

With respect to either parameter, tree A, the tree of Scottish data does not differ from random data. By contrast, tree D has significantly less branching points and more chain segments than expected.

Table 2
Nearest neighbour tree statistics

Fig.3A: Scotland

Points:	31	
Branching points:	5	Expected range (*): 4 to 7
Chain links:	15	Expected range (*): 11 to 17

*Mean +- std for 31 points.

Fig.3D: Alpine range

Points:	38	
Branching points:	4	Expected range (*): 5 to 8
Chain links:	26	Expected range (*): 13 to 19

*Mean +- std for 38 points.

The summit level (gipfelflur) defined by paramount peaks

It has been noted that the highest peaks in some mountain areas seem to be lined up at a certain level. This nearly horizontal surface, the summit level, or gipfelflur, was taken to indicate the earliest erosion surface traceable. The application of this pleasing concept has however met some problems; it is difficult to decide which peaks are defining the summit level, and the surface across the peaks is not as flat as one would wish it to be. One possible way to select summits is to take the highest point in, say, each 10*10 km square (Gunnell 1997).

As shown above, paramount peaks are defined by objective criteria, and thus could be ‘natural’ candidates, offering a selection of peaks that overcomes the first of these problems. On the other hand, the paramount peaks being of very unequal height, the surface defined by them could not be expected to be smooth.

Figure 4 shows the contour map fitted to the 31 paramount peaks by a mainstream contouring algorithm. Each colour band represents an interval of 90 m.

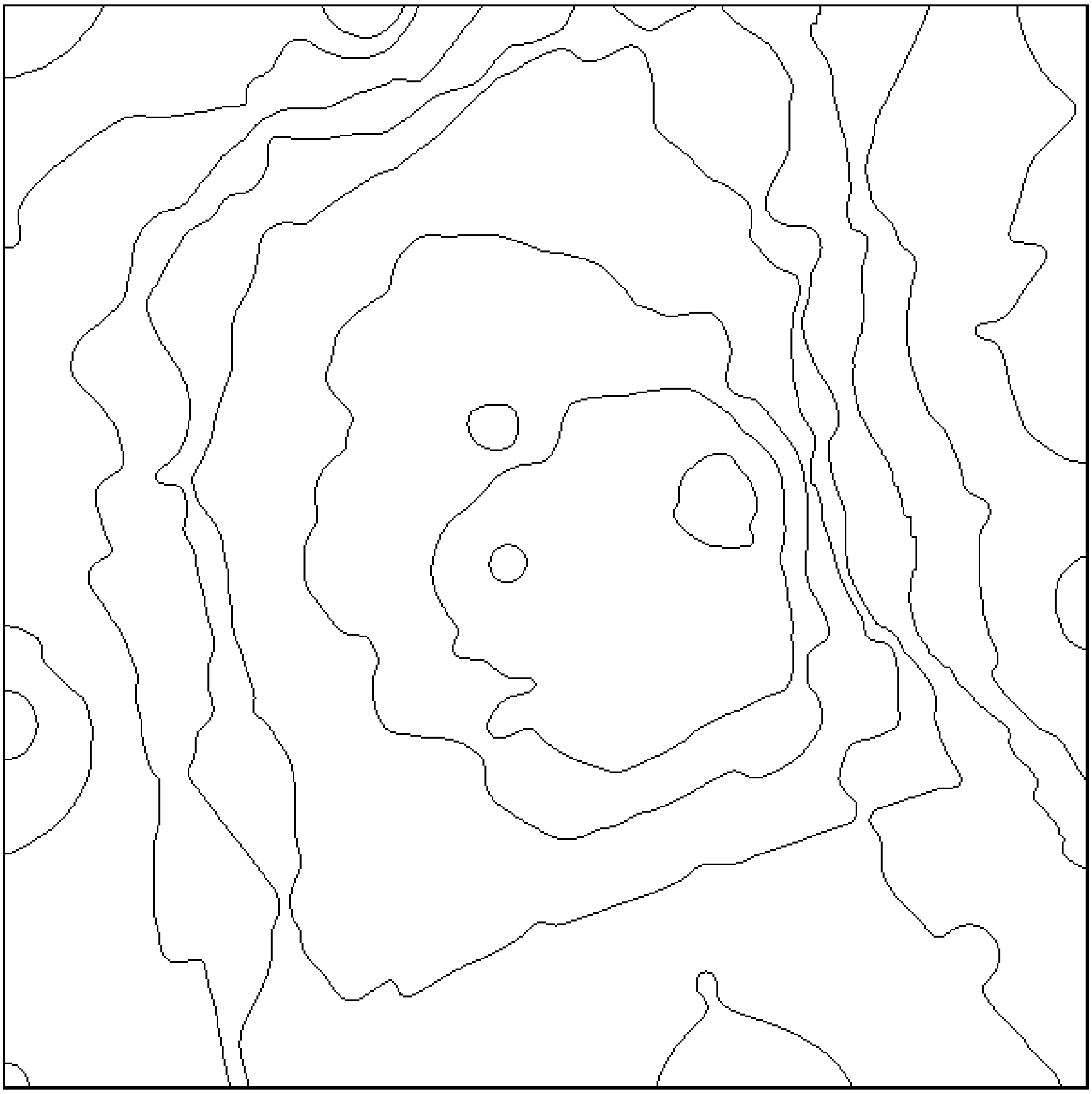

Figure 4. Contour map of the summit level

The most striking feature of the map is a fairly extensive plateau occupying most of the mainland, with two maxima centred on Ben Nevis and Ben Macdhui.

North and south of the highest point the surface is not a perfect plane, but gently sloping away from the centre, as expected from an ancient erosion surface. The summit level is so smooth that it is hardly dented even by such major valleys as the Midland Valley and the Great Glen. This, and the fact that the paramount peaks consist mostly of pre-Carboniferous rocks, indicates an early age for the summit level.

The eastern and western slopes are steeper and present a complication. The abrupt slopes may be interpreted as the breaking up of the original surface by later events, in the east by the sinking of the North Sea and the opening of the Atlantic Ocean on the western side, which also caused the Tertiary volcanism. On the other hand, the nature of the data may have caused the contouring algorithm to create uncertain contours (artefacts) in the east and west.

References

Adam J.A. 2003
Mathematics in Nature
Princeton University Press, Princeton, 2003, 360 p.

Close C.F. & Cox E.W. 1913
Text Book of Topographical and Geographical Surveying
HMSO, London, 1913, 412 p.

Devdariani A.S. [Ed.] 1967
Rel'ef Zemli i matematika
Mysl', Moskva, 1967, 116 p.

Finckl C.W. 1982
On the geomorphic stability of cratonic planation surfaces
Z. Geormorph., vol.26, no.2, pp.137-150

Frisch W. [Ed.] 1997
Tectonic Geomorphology. Proc. 4th Intl. Conf. Geomorph. Vol. III.
Z. Geomorph. NF Suppl., no. 118, 268 p.

Gunnel, Y. 1997
Topography, palaeosurfaces and denudation over the Karnataka uplands, southern India
in: Widdowson, M. [Ed]: Palaeosurfaces: Recognition, Reconstruction and Palaeoenvironmental Interpretation, pp.249-267

Jordan Gy., Csillag G. & al.
Application of digital terrain modelling and GIS methods for the morphotectonic investigation of the Kali Basin, Hungary
Z. Geomorph., vol.47, no.2, 2003

Ringrose, P.S. & Migon, P. 1997
Analysis of digital elevation data from the Scottish Higlands and recognition of pre-Quaternary elevated surfaces
in: Widdowson, M. [Ed]: Palaeosurfaces: Recognition, Reconstruction and Palaeoenvironmental Interpretation, pp.25-35

Simon-Coincon R. 1999
Palaeolandscape reconstruction of the south-western Massif Central (France)
Spec. Publ. Intl. Ass. Sediment., vol.27, pp.225-243, 1999

Small R.J.
The Study of Landforms
Cambridge University Press, London, 1974, 486 p.

Widdowson, M. [Ed] 1997
Palaeosurfaces: Recognition, Reconstruction and Palaeoenvironmental Interpretation
Geological Society, London, 1997, 330 p

Wooldridge S.W. 1950
The upland plains of Britain; their origin and geographical significance
The Advancement of Science, vol. 7, pp.162-175

Websites:

Scotland's Marilyns and Munros.
www.climb.mountains.com

Rachford B.
When is a mountain really a molehill?
www.eskimo.com/~rachford/mountaineering/essays

SRTM30
ftp://e0srp01u.ecs.nasa.gov/srtm/srtm30/

SRTM3
ftp://e0srp01u.ecs.nasa.gov/srtm/version2/

Topographic prominence
http://en.wikipedia.ork/wiki

Visible UTM mosaic (Landsat 1990/2000 processed data)
https://zulu.ssc.nasa.gov/mrsid/

(Elevation Models For Geoscience Conference, 23 March 2006, London. p.11)

QVOL: A quick tour

T. Jasko

The following quick tour shows the most important features of QVOL using the example files provided (these are usually installed in the folder C:\Quartz\Qexample).

The exercise: Compute the volume of the gas cap and the oil zone for a 37 m thick reservoir bed of parallel top and base. The contour map of the top is a scanned bitmap (.bmp) file.

Planimetry of scanned top

From the QVOL menu select Horizon / Scan and open the coloured bitmap Stake.bmp. The program displays the image and performs planimetry by measuring the area of colour patches within the black borders.

Enter the values for tops in the colour coded boxes on the left e.g. 870 (the very top of the structure, usually not a round number), 900, 1000, 1100 and so on; except for the box coloured black, where enter -1.

When all horizon tops are completed, enter Map scale: 25,000. Press OK, and save the data as Stake.sac.

Create Base Horizon by depth shift

Select Horizon/Edit and open the horizon data file Stake. Press Shift to perform Depth shift. Enter the value 37. Change Horizon name to “Stake-B”, and save the data as StakeB.sac.

Edit Structure

Select Structure/Edit and open a structure data file e.g. Sandwell.rid. In the list of horizons enter (or select from drop down list) Stake, then StakeB. Check that the Depth range and Area ranges are correct. E.g. the depth range can be 800 to 1300, the Area range 0 to 2.5. Enter the depth of contacts e.g. '987 gas/oil contact' and '1032 oil/water contact'. Check 'Boxed display'. Then save the data as Starking.rid.

Area/Depth plot.

From the Structure menu select Area/Depth plot and open Starking.rid. The plot will be displayed on the screen with boxes listing areas and volumes. There will be two figures in the Volume box under the top horizon name (Stake). The upper one is the gross rock volume above the gas/oil contact (gas cap), the next one is the gross rock volume between the gas/oil and oil/water contacts (oil zone).

Print the Area/Depth plot displayed on screen by clicking Print. If you want to print in colour, set the print option in Options to colour.

Volume/Closure plot

From the Structure menu select Volume/Closure plot and open the structure file as before. (You can change the displayed range by editing the structure file). Print the plot as above.
(Quartz Scientific, Watford, 2004, 2 p.)

Construction Materials Group: The history of the London Underground

Clemency Christopherson
SCI Communications Executive

With Christmas only two weeks away and the start of a New Year beckoning, the Construction Materials Group ended 2005 on a high note. Stephen Halliday, author of Underground to everywhere, delighted over 100 listeners with his talk “Fraud, suicide, bankruptcy and transportation for life: the controversial history of the London Underground railway”.

From Paxton to Pick, Halliday illustrated the colourful history of the London Underground from the Victorian age to the present day. With the opening statement “Ken Livingstone is a pussycat compared to his predecessors”, the audience were introduced to the many characters who contributed to the conception and realisation of our underground network.

This fascinating lecture highlighted the forward thinking needed to establish a system that transports over three million commuters a day. The talk highlighted the work of many innovators, from Sir Joseph Paxton, creator of the Crystal Palace, who envisaged a pneumatic railway encased in glass, to Marc Brunel whose rotary excavator is still used as the basis of tunnelling technology. It embraced key contributors such as Charles Tyson Yerkes, who funded the completion of four tube lines through embezzled money, and Frank Pick, who established the corporate image by commissioning works by artists such as Graham Sutherland and Lucie Atwell.

Halliday spoke of particular factors that hindered progress, including the issues of cost and safety, political influence on management decisions (delaying the Victoria line for 20 years), under investment and "annuality", which in turn led to privatisation. We were also reminded of the sanctuary the underground provided during the blitz.

It was a double celebration for the Construction Materials Group as committee member Iren Jasko (below) was awarded the Distinguished Service Award in recognition of her invaluable contribution to SCI. Presented by Ed Metcalfe, Chairman of Council, and surrounded by family and friends, Jasko spoke of the important role SCI had played in her life and looked forward to the continuing growth and prosperity of the Society.

(The Loop, no. 21, 2006, p.12)

Gairloch says farewell to museum boss

Martha Jasko, curator of the Gairloch Heritage Museum for the last two-and-a-half years, held a farewell party for colleagues this week. She is leaving to take up a post as assistant museums manager at Buxton Museum and Art Gallery.

She was brought up in Watford, daughter of Hungarian parents.

Following her appointment in 2002 as curator of the Heritage Museum Martha quickly adapted herself to life in the north-west Highlands.

Martha Jasko and local councillor Roy MacIntyre (seated) with some of her colleagues from the Gairloch Heritage Museum. *Pic by Colin Robertson*

She has proved to be a very capable curator, popular with voluntary staff and visitors, and the new ideas and approaches that she adopted at the museum have been much appreciated by visitors.

Her outgoing personality has enabled her to participate in community activities outside her work, and she will be greatly missed by colleagues at Two Lochs Radio and at the Air Training Corps as well as by the Trustees and voluntary staff at the museum.

(Ross-shire Journal, 2005)