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TECHNICAL COMMUNICATIONS

Improving the Traversing Micro-Erosion Meter

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ABSTRACT

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A traversing micro-erosion meter has been fitted with an electronic digital dial gauge so readings can be logged to a laptop computer. This facilitates rapid collection and analysis of data of erosion rates on shore platforms. Data analysis is enhanced by using 3-D plotting software to calculate volumes of material being eroded and to investigate processes of erosion.

INTRODUCTION

The micro-erosion meter was first described by HIGH and HANNA (1970) and used to measure relatively slow rates of lowering on rock surfaces caused by a variety of erosion processes. Subsequently, ROBINSON (1976), KIRK (1977), GILL and LANG (1983), VILES and TRUDGILL (1984), SPATE *et al.* (1985), and MOTTERSHEAD (1989) used the technique to investigate processes and rates of erosion on shore platforms. All these investigations utilised manual methods of data collection. This paper describes modifications that were made to allow data to be logged digitally to a laptop computer. This was done as part of an investigation of erosion rates on shore platforms around Kaikoura Peninsula, on the east coast of the South Island, New Zealand. The study utilises 42 micro-erosion meter measuring sites. The traversing micro-erosion meter currently in use allows 120 positions to be located per measuring site, so that 42 micro-erosion meter sites yield a total of 5,040 readings per survey. Manual recording of such a large data set was considered to be too time consuming. Analysis is being undertaken to calculate the volume of material being eroded from each micro-erosion meter site, to derive a mean erosion rate on shore platforms on the Kaikoura Peninsula and to provide an insight into processes of erosion acting on the shore platforms.

THE MICRO-EROSION METER

The micro-erosion meter (Figure 1) consists of an equilateral triangular base with legs located at each corner and an engineering dial gauge located on a central pillar. The spindle of the gauge extends through the base plate. Readings are taken by placing the base on three bolts permanently fixed into a rock surface. Exact relocation on the fixed bolts is obtained by using the Kelvin Clamp Principle. The end of each leg has been machined differently; one has a cone shaped depression, and the other a v-notch depression and the third is flat (HIGH and HANNA, 1970). Each leg end opposes movement in three, two and one direction respectively; thus, preventing movement of the plate when placed on a bolt site. In the original design, the engineering dial gauge was located off centre in the base plate so that three readings could be obtained by rotating the instrument on the bolts (HIGH and HANNA, 1970).

TRUDGILL *et al.* (1981) presented a modified version of the micro-erosion meter, the traversing micro-erosion meter. The traversing micro-erosion meter differs in that the dial gauge is independent of the base and is mounted with three arms separated at 120° intervals (Figure 2). The dial gauge can be moved to a number of different positions by locating each horizontal arm between ball bearings fixed along the sides of the base. The centre of the base plate is cut out to allow the dial gauge to be moved within the area defined by the permanent bolts. As long as each arm is at right angles to a side of the triangular base, a precise location is obtained each time the instrument is placed on a bolt site. The number of locations depends on the size of the base, the number of ball bearings fixed along each edge and on the size and configuration of the dial gauge and arms.

The sides of the base plate are labeled clockwise A, B, and C, and the spaces between ball bearings are numbered clockwise. At present an instrument of the traversing type being used at Kaikoura has 15 positions along each side (16 ball bearings). A labeled position at which a measurement is taken would be in the form A12, B4, C8. The first set of data

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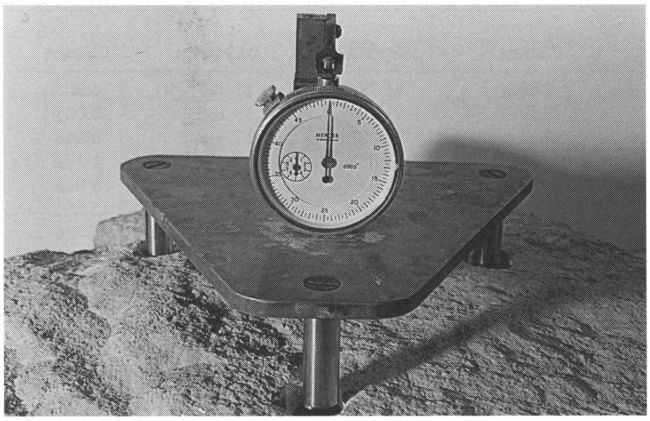

Figure 1. The micro-erosion meter.

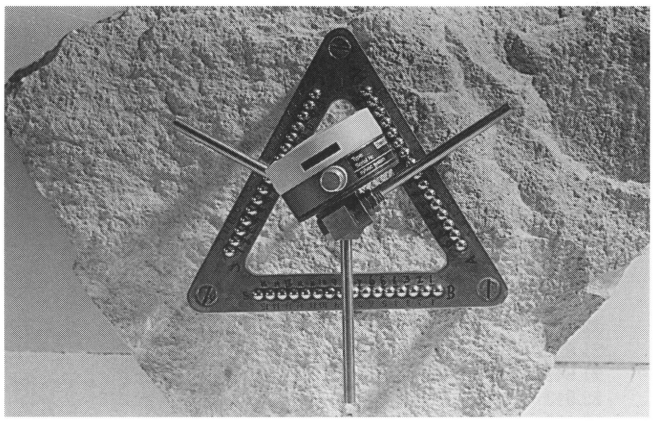

Figure 2. The traversing micro-erosion meter.

Table 1. *Example of a spread sheet template with micro-erosion meter site details, position labels and collected data.*

Profile KM1 Site No A Date 1/4/94					
A Reference	Measure	B Reference	Measure	C Reference	Measure
A13/B3/C8	14.628	B13/C3/A8	13.917	C13/A3/B8	10.404
A12/B4/C8	15.108	B12/C4/A8	13.973	C12/A4/B8	8.931
A12/B5/C7	14.889	B12/C5/A7	14.137	C12/A5/B7	13.076
A11/B4/C9	14.658	B11/C4/A9	13.982	C11/A4/B9	8,525
A11/B5/C8	14.883	B11/C5/A8	13.920	C11/A5/B8	13.545
A11/B6/C7	15.231	B11/C6/A7	14.574	C11/B6/A7	14.855
A11/B7/C6	15.139	B11/C7/A6	14.643	C11/A7/B6	15.271
A10/B5/C9	14.730	B10/C5/A9	14.055	C10/A5/B9	13.059
A10/B6/C8	15.263	B10/C6/A8	14.528	C10/A6/B8	15.043
A10/B7/C7	15.557	B10/C7/A7	14.487	C10/A7/B7	15.249
A10/B8/C6	15.046	B10/C8/A6	15.084	C10/A8/B6	14.732
A10/B9/C5	14.979	B10/C9/A5	15.429	C10/A9/B5	14.965
A9/B5/C10	14.493	B9/C5/A10	13.913	C9/A5/B10	11.390
A9/B6/C9	14.909	B9/C6/A9	14.648	C9/A6/B9	15.018
A9/B7/C8	15.212	B9/C7/A8	14.687	C9/A7/B8	15.757
A9/B8/C7	15.355	B9/C8/A7	15.038	C9/A8/B7	15.060
A9/B9/C6	14.930	B9/C9/A6	15.069	C9/A9/B6	14.618
A9/B10/C5	15.269	B9/C10/A5	15.466	C9/A10/B5	14.643
A9/B11/C4	15.605	B9/C11/A4	15.309	C9/A11/B4	14.967
A8/B6/C10	14.499	B8/C6/A10	14.762	C8/A6/B10	13.719
A8/B7/C9	14.548	B8/C7/A9	15.453	C8/A7/B9	15.441
A8/B8/C8	14.284	B8/C8/A8	15.579	C8/A8/B8	15.350
A8/B9/C7	13.522	B8/C9/A7	15.191	C8/A9/B7	14.825
A8/B10/C6	13.828	B8/C10/A6	15.000	C8/A10/B6	14.150
A8/B11/C5	13.785	B8/C11/A5	15.172	C8/A11/B5	14.113
A8/B12/C4	13.570	B8/C12/A4	14.756	C8/A12/B4	14.656
A7/B6/C11	13.070	B7/C6/A11	14.921	C7/A6/B11	13.294
A7/B7/C10	12.816	B7/C7/A10	15.751	C7/A7/B10	14.895
A7/B8/C9	12.150	B7/C8/A9	15.979	C7/A8/B9	14.969
A7/B9/C8	10.749	B7/C9/A8	15.931	C7/A9/B8	14.751
A7/B10/C7	10.748	B7/C10/A7	15.122	C7/A10/B9	14.133
A7/B11/C6	11.019	B7/C11/A6	14.995	C7/A11/B6	13.903
A6/B7/C11	7.931	B6/C7/A11	14.722	C6/A7/B11	14.016
A6/B8/C10	9.442	B6/C8/A10	15.708	C6/A8/B10	14.568
A6/B9/C9	9.373	B6/C9/A9	15.918	C6/A9/B9	14.634
A6/B10/C8	9.286	B6/C10/A8	15.243	C6/A10/B8	14.147
A5/B7/C12	10.657	B5/C7/A12	12.180	C5/A7/B12	12.863
A5/B8/C11	11.465	B5/C8/A11	12.535	C5/A8/B11	13.993
A5/B9/C10	10.745	B5/C9/A10	13.976	C5/A9/B10	14.246
A4/B8/C12	11.607	B4/C8/A12	9.998	C4/A8/B12	12.791

is taken along the "A" side of the base. For this to occur the dial gauge faces the flat leg, or the leg labeled "A". The base plate is always located on a bolt site with leg "A" pointing seaward. In all, forty readings can be taken off each side of the base plate. This is achieved by keeping the arm, in the case of the "A" side of the base plate, in the same position and moving the other two arms away from the "A" side. Thus a series of readings off one position on the "A" side would be, A8/B6/C10; A8/B7/C9; A8/B8/C8; A8/B9/C7; A8/B10/C6; A8/B11/C5 and A8/B12/C4 (Table 1). The gauge is then rotated 120° so that the dial gauge faces the wedge shape leg (Leg B) and then the second set of data is taken off the B side, (for example B12, C4, A8). The third set of data is taken off the B side; the dial gauge is rotated to face the cone shaped leg (Leg C), and all readings are taken off the C side of the base (for example C12, A4, B8). It should be noted that the same sequence of numbers such as B12, C4, A8 and C12, A4, B8 does not represent the same position. This is because the spindle of the dial gauge is off centre from the junction of the three arms.

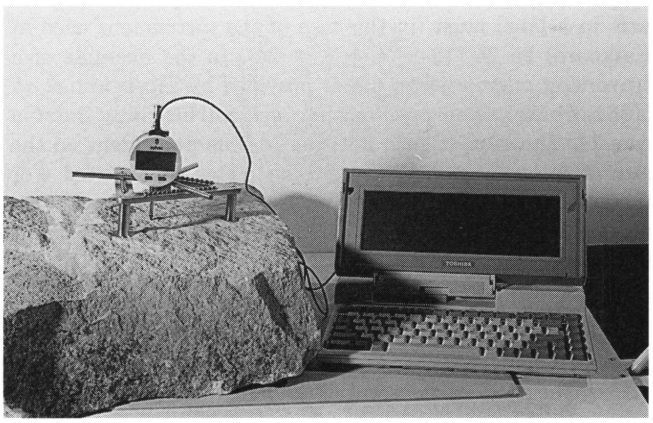

Figure 3. The traversing micro-erosion meter with digital gauge and laptop computer.

Table 2. *Results from successive readings from a micro-erosion meter site at Kaikoura. All readings are in millimeters.*

KM6A 28/12/93	04/04/94	Change	28/12/93	04/04/94	Change	28/12/93	04/04/94	Change
21.678	17.999	3.679	22.26	18.658	3.602	21.726	17.473	4.253
21.856	18.241	3.615	23.069	19.352	3.717	21.232	18.135	3.097
22.157	18.684	3.473	21.686	17.876	3.81	21.262	17.819	3.443
21.645	18.032	3.613	22.477	17.617	4.86	21.383	17.211	4.172
21.932	18.531	3.401	21.393	18.002	3.391	21.949	18.004	3.945
22.469	18.743	3.726	22.056	18.518	3.538	20.898	17.647	3.251
22.603	18.777	3.826	22.506	18.483	4.023	20.849	17.39	3.459
21.749	18.451	3.298	22.6	18.733	3.867	21.184	17.455	3.729
22.233	18.596	3.637	22.606	18.846	3.76	22.377	18.442	3.935
22.176	18.788	3.388	22.55	18.742	3.808	22.639	18.767	3.872
22.115	18.425	3.69	22.465	18.775	3.69	21.41	17.936	3.474
21.623	17.898	3.725	22.117	18.142	3.975	20.724	16.959	3.765
21.642	18.304	3.338	22.631	18.789	3.842	22.307	18.081	4.226
22.013	18.508	3.505	22.682	18.759	3.923	23.938	18.892	5.046
22.328	18.504	3.824	22.66	18.767	3.893	21.729	18.138	3.591
22.047	17.959	4.088	22.825	18.919	3.906	22.61	18.583	4.027
21.906	16.918	4.988	22.538	18.661	3.877	22.935	18.889	4.046
21.202	16.808	4.394	22.44	18.695	3.745	20.517	17.71	2.807
21.517	17.449	4.068	22.205	18.635	3.57	21.258	18.367	2.891
21.684	18.473	3.211	22.37	18.788	3.582	22.018	18.577	3.441
21.08	17.692	3.388	22.533	18.765	3.768	23.312	19.771	3.541
20.2	16.72	3.48	22.482	18.725	3.757	23.124	18.652	4.472
21.485	17.696	3.789	22.368	18.643	3.725	22.516	18.411	4.105
21.602	18.019	3.583	22.347	18.711	3.636	22.849	18.756	4.093
20.862	17.564	3.298	22.244	18.571	3.673	20.473	17.367	3.106
20.71	17.867	2.843	22.412	18.321	4.091	21.189	18.109	3.08
21.301	18.409	2.892	22.481	18.67	3.811	21.21	18.348	2.862
19.837	16.377	3.46	22.294	18.635	3.659	22.718	19.325	3.393
21.179	18.05	3.129	22.403	18.56	3.843	22.886	19.332	3.554
21.658	18.224	3.434	22.238	18.444	3.794	22.519	18.508	4.011
21.298	18.059	3.239	22.037	18.391	3.646	21.37	18.283	3.087
21.086	17.713	3.373	22.466	18.79	3.676	21.576	18.845	2.731
20.484	17.772	2.712	22.465	18.804	3.661	21.783	18.679	3.104
21.457	18.384	3.073	22.226	18.411	3.815	22.481	19.68	2.801
21.519	18.226	3.293	22.106	18.173	3.933	20.923	18.242	2.681
21.126	17.434	3.692	22.876	18.781	4.095	22.062	18.847	3.215
20.486	18.093	2.393	23.355	19.137	4.218	21.802	18.805	2.997
21.237	18.447	2.79	23.192	19.434	3.758	22.49	19.142	3.348
21.316	18.185	3.131	23.504	19.945	3.559		Mean Change	3.598
21.05	18.555	2.495	21.279	17.478	3.801		Minimum Change	2.393
22.236	18.599	3.637	20.942	17.707	3.235		Maximum Change	5.046

TRUDGILL *et al.* (1981) provided a system to check with each of the three arms on the dial gauge that a proper location has been obtained. The sum of the three positions of each arm in a label must (in the case of the instrument used at Kaikoura) be 24 (12 + 4 + 8 = 24). In the example of a traversing micro-erosion meter provided by TRUDGILL *et al.* (1981) which had six positions between ball bearings, the sum was 11. The sum of each position is thus dependent on the size of the traversing micro-erosion meter constructed. For the present study, a square was used to ensure that each arm was perpendicular to a side of the base plate before calculating the sum of the sides.

MODIFICATIONS TO THE TRAVERSING MICRO-EROSION METER

Previous published designs of the micro-erosion meter have used an analogue dial gauge which required the operator to read and physically record results. This is considered to be too restrictive given the time constraints of working on shore platforms in the inter tidal zone where large data sets are desired to improve knowledge of erosion. To overcome this, the micro-erosion meter currently in use was fitted with a digital dial gauge (Figure 3). Such gauges are readily available from suppliers of engineering tools. The gauge in use at Kaikoura is manufactured by SYLVAC, has a range of 25–0.001 mm or 1–0.0005″ and is accurate to 0.001 mm. The digital dial gauge is connected to a laptop computer via an optical RS 232 cable (Figure 3). Each reading is logged directly to a spreadsheet using software supplied with the gauge. At present, a spreadsheet template is used for each micro-erosion meter site. The spreadsheet contains labels for each position of the gauge, a site label and date (Table 1). When readings have been taken, the template is saved as the site location label.

As well as speed of use, there are a number of other advantages resulting from this modification. One source of error is removed from the technique in that the operator is no longer required to read an analogue face. This entails a degree

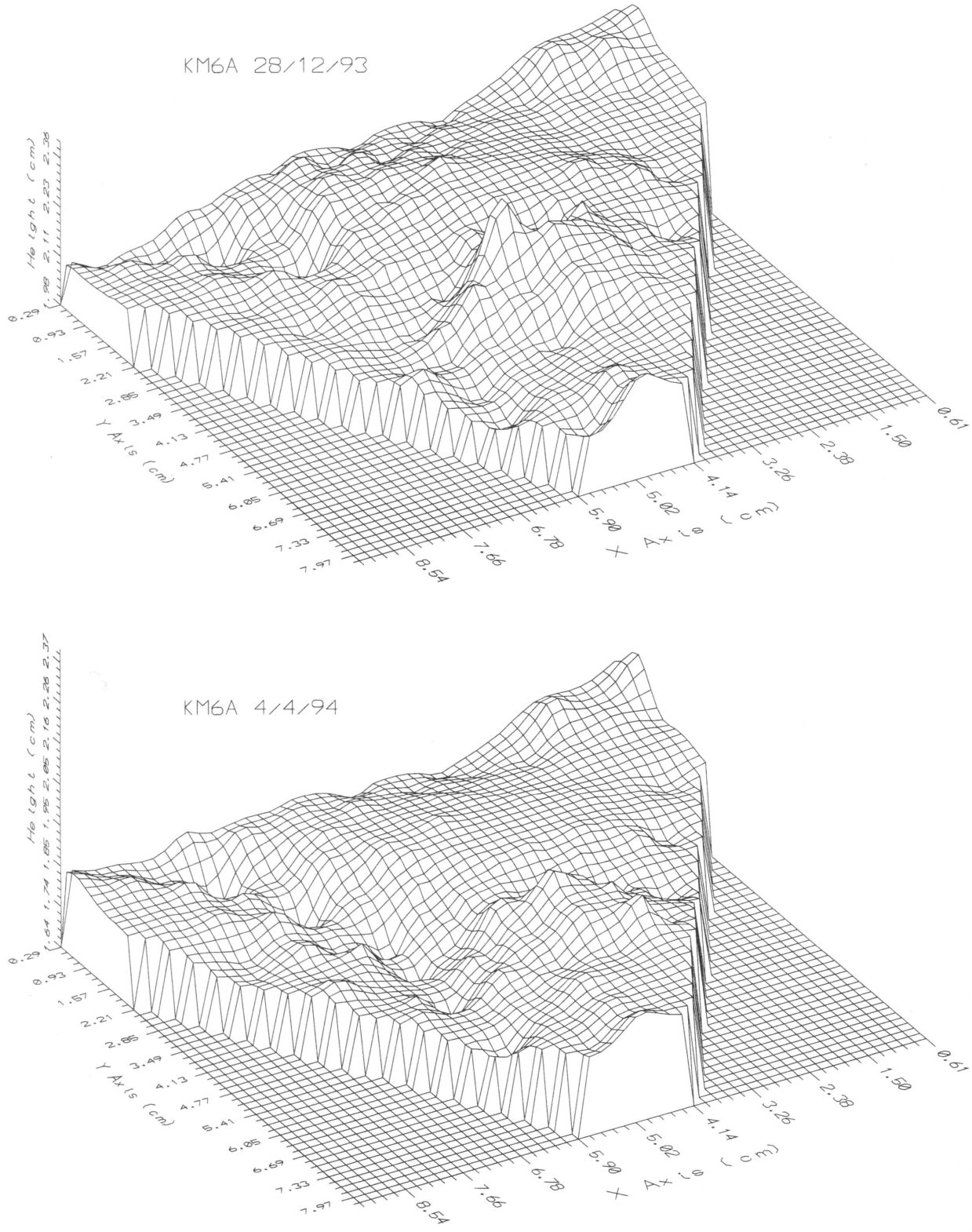

Figure 4. Graphical output from SURFER showing actual topography of two successive readings from a traversing micro-erosion meter site. Vertical exaggeration equals 6.

Table 3. *Surfer output of volume and surface area data.*

```
Volume computations
  Time of logging: Mon May 09 10:11:09 1994
Upper surface
    Grid File: C:\KM6A1.GRD
      Rows: 1 to 32767
      Cols: 1 to 32767
    Grid size as read: 50 cols by 50 rows
      Delta X: 0.176115
      Delta Y: 0.159944
      X-Range: 0.614978 to 9.24462
      Y-Range: 0.288978 to 8.12623
      Z-Range: 1.9848 to 2.37474
Lower surface
    Grid File: C:\KM6A2.GRD
      Rows: 1 to 32767
      Cols: 1 to 32767
    Grid size as read: 50 cols by 50 rows
      Delta X: 0.176115
      Delta Y: 0.159944
      X-Range: 0.614978 to 9.24462
      Y-Range: 0.288978 to 8.12623
      Z-Range: 1.63907 to 1.99396
Volumes
  Approximated Volume by
    Trapezoidal Rule: 16.6361
    Simpson's Rule: 16.6383
    Simpson's 3/8 Rule: 16.6457
Surface computations
  Time of logging: Tue May 10 11:37:08 1994
    Grid file: C:\KM6A1.GRD
      Rows: 1 to 32767
      Cols: 1 to 32767
    Grid size as read: 50 cols by 50 rows
      Delta X: 0.176115
      Delta Y: 0.159944
      X-Range: 0.614978 to 9.24462
      Y-Range: 0.288978 to 8.12623
      Z-Range: 1.9848 to 2.37474
    Constant Level: 0
      Log file: MEM2D.LOG
  Computed surface area above level: 45.7254
  Computed surface area below level: 0
Surface area computations
  Time of logging: Tue May 10 11:37:24 1994
    Grid file: C:\KM6A2.GRD
      Rows: 1 to 32767
      Cols: 1 to 32767
    Grid size as read: 50 cols by 50 rows
      Delta X: 0.176115
      Delta Y: 0.159944
      X-Range: 0.614978 to 9.24462
      Y-Range: 0.288978 to 8.12623
      Z-Range: 1.63907 to 1.99396
    Constant Level: 0
      Log file: MEM3D.LOG
  Computed surface area above level: 45.6836
  Computed surface area below level: 0
```

of interpretation in reading to three decimal places. Reading errors may be larger if more than one operator is involved in collecting data. It is also possible to obtain results immediately in the field by setting up a spreadsheet with the last set of data collected and logging the new set alongside the last set collected. Repeated readings at each label position provides a check on the integrity of the data. This also helps to ensure that the dial gauge is positioned correctly. Positioning is important as the operator has to handle the dial gauge during readings in order to log the result to the laptop computer.

ANALYSIS OF DATA

The collected data already in a spreadsheet, calculating statistics such as the mean erosion rate for a bolt site and all bolt sites, becomes instant by adding the appropriate equation into the spreadsheet. TRUDGILL *et al.* (1981) indicated that data obtained from the traversing micro-erosion meter provide an opportunity to examine the micro relief of a micro-erosion meter site and provide a means of identifying erosion processes. How well this can be done clearly depends on the spatial and temporal sampling densities achievable in the field.

To examine how the surface of a site erodes, the data are displayed as successive 3-D surface plots using a plotting program. The software used is SURFER, from Golden Software, Colorado, USA. The detailed use of SURFER to represent coral reefs was presented by ISDALE (1991). The input variables for this program are x, y, and z co-ordinates. Co-ordinates x and y represent positions of the dial gauge in the horizontal plane. The z axis is the vertical reading given by the gauge which is in reference to the position of the probe when it is at zero, or at rest. Recorded results can be plotted directly into SURFER giving a graphical representation of bolt site surface. Within SURFER, vertical exaggeration can be applied and is often necessary to emphasis detail on "smooth" surfaces.

SURFER allows the volume of a plot to be calculated and also the difference in volume between successive plots. SURFER utilises three methods for calculating volumes and each generates slightly different results. These methods are discussed in the accompanying manual. It is therefore possible to calculate the volume of material eroded from each bolt site, which may provide an insight into the contribution of shore platforms to local sediment budgets around the Kaikoura Peninsula. It is also possible to overlay successive plots and visually interpret changes in a surface over time. This can also be investigated by using SURFER to calculate surface areas of bolt sites. High or low surface areas may give an indication of the morphology of a surface as well as changes in morphology. Marked changes in surface areas may indicate changes in the type of erosion at a bolt site. The geomorphic significance of these types of analyses is at present under consideration.

AN EXAMPLE WITH DATA FROM KAIKOURA

Table 2 presents the results of two successive micro-erosion meter readings from a site located on a rapidly eroding Mudstone shore platform at Kaikoura. The results show the net erosion at each position over 97 days. The mean rate of erosion for the site was 3.598 mm the minimum 2.393 mm and the maximum 5.046 mm. Figure 4 show the surfaces plotted from both sets of data. Table 3 is an example of the output

of SURFER and provides the net change in volume between the two plots and respective surface areas. It can be seen that the net erosion of material was 16.6 cm^3. The surface areas were 45.72 cm^2 and 45.68 cm^2, respectively.

CONCLUSIONS

The modifications to the traversing micro-erosion meter described allow rapid collection and analysis of data. This is particularly useful when a large data set is being collected, such as that being generated at Kaikoura, and previous studies have been hampered by low spatial and temporal erosion data sampling rates. Data in digital form provides access to many new forms of manipulation and visualisation. Analysis of erosion data using SURFER provides one new set of insights into erosion rates and processes on shore platforms. The developments reported here help to overcome a scarcity of quantitative data in shore platforms studies generally. The use of the traversing micro-erosion meter is not limited to shore platforms; the analysis described here can be applied in many different environments.

ACKNOWLEDGEMENTS

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