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Résumé de l'article

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Reports

A MODIFIED ONE MAN BEACH PROFILING METHOD

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A rapid one-man, beach profiling method is presented. The scheme is based upon a 1.5 x 1.5-m H-shaped frame and uses the earth's horizon as a level. A small correction must be applied to readings to correct for the Earth's curvature. Measurement error in the method decreases with increased packing of sediment but is independent of grain size. Profiles plotted using this scheme are replicable and similar in slope and shape to ones surveyed using instrument levelling.

INTRODUCTION

In beach studies it is often convenient for one person to measure beach profiles or slopes efficiently. Two basic profiling systems have been developed for this purpose. The first, known commonly as the "Emery" method (Emery 1961), is based upon the relative heights of two graded poles along a profile and uses the Earth's horizon as a reference. The second is based upon changes in angle with distance along a slope and employs an "A" frame (Pitty 1968, Riley 1969), a rectangular frame (Schwartz 1966, Harrison and Boon 1972) or a pegging scheme (Stephens 1977). Both systems are portable, simply operated and versatile. The Emery method has a distinct advantage on low angle slopes, as it involves direct measurement of changes in elevation and thus precludes the large errors introduced by subjective discernment of angle variations on gentle slopes. The method is limited only by the fact that an open horizon must be readily visible to the observer.

The Emery method commonly requires two people to operate. This paper presents a modification which will allow one person to survey profiles with considerable efficiency. The basic theory behind the method will be outlined first. Then the replication accuracy will be assessed by comparing the technique to instrument levelling for various slopes and beach materials. Finally a simple FORTRAN IV computer program for calculating the corrections needed to plot the profiles will be presented.

THEORY AND DESCRIPTION OF METHOD

Emery (1961) took advantage of the fact that the Earth's horizon could be used as the "level" in level-and-stadia rod profiling on a beach. Two graded rods of equal length, placed a known distance from each other, are used to determine the difference in elevation and distance between two points. By standing at the shoreward end and aligning the rods normal to shore, one can profiles both negative and positive slopes. For negative slopes, the horizon is aligned with the top of the seaward pole and the change in elevation is read off the shoreward pole. For positive slopes the procedure is reversed and the horizon is aligned with the top of the shoreward pole and the change in elevation read off the seaward pole. If the distance between the poles remains fixed, then a profile can be surveyed by successive steps normal to shore.

Usually two men are required to move the poles down the beach; however, if the two poles are joined together using two hinging struts of equal length, then it is possible for one observer to walk the resulting H-shaped frame in increments, seawards, down the profile (Fig. 1). The H-shaped frame consists of two poles, each 1.5-m in length and 2.0-cm square. The length of each pole is painted along one side with alternating red and white 1-cm thick strips and marked off at 10-cm intervals. Two struts, each 1.43-m in length and 2.0-cm square, with 3.5-cm strips of aluminum at each end, are bolted 0.2 and 0.5 m from the top and bottom respectively of each pole. The resulting frame measures 1.5 x 1.5 m and can be easily assembled or dismantled for profiling and transporting. By measuring only the apparent change in elevation between the two poles for successive increments, one person can readily survey elevation changes with distance along the complete profile. A tape recorder can be used to record all readings.

Because of the curvature of the Earth, one height correction must be made for each change in apparent elevation. While the correction is small, cumulated errors in elevation can amount to 6-8 cm along a 100-m profile. Once this correction has been made, the actual distance between the two poles can be calculated using the following formulae:

$$d = c/\mathrm{TAN}\alpha$$
$$c = a+b \quad \text{or } c = a-b \text{ (positive slopes)}$$
$$b = d/\mathrm{TAN}\phi$$
$$\phi = \mathrm{ASIN}\ (r/s)$$
$$s = r+Ph+h_{j-1}+sum \quad \text{or } s = r+Ph+h_{j-1}-a+sum \text{ (positive slopes)}$$
$$\alpha = \mathrm{ASIN}\ (c/f)$$

a = apparent change in height in meters
b = correction for Earth's curvature in meters
c = actual change in height
d = actual distance over which change in height occurs
f = length of struts joining the two "Emery" poles
Ph = height of "Emery" pole
r = radius of Earth (6371229m at 30 degrees latitude)
sum = Σb for previous readings on profile

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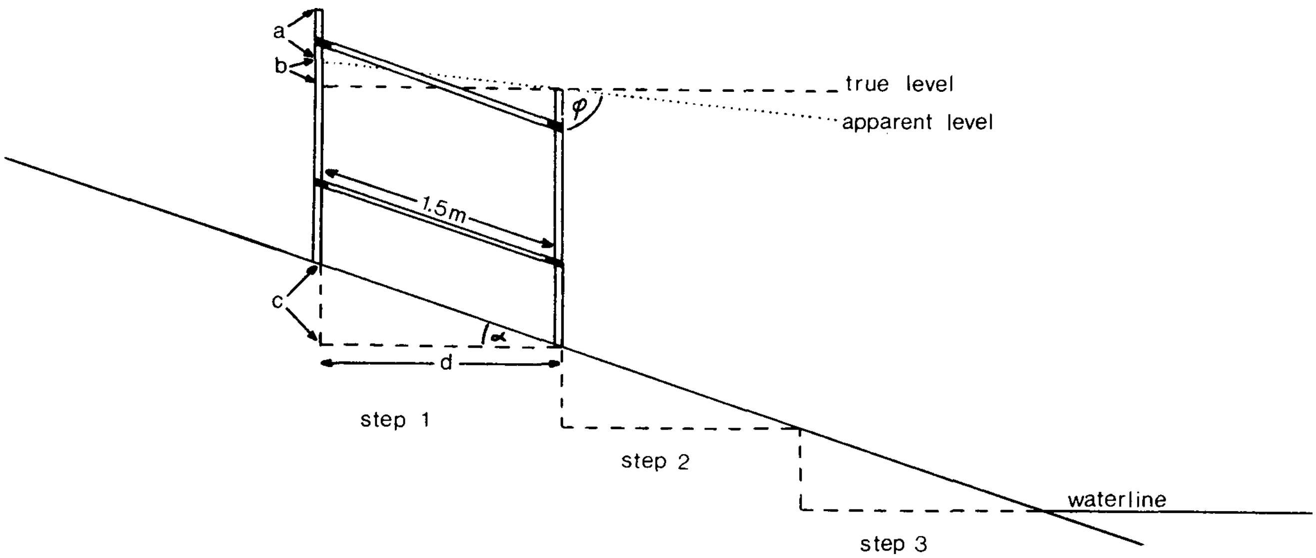

FIG. 1 Outline of modified Emery method of profiling

h_{j-1} = corrected elevation of nearest seaward reading

α = beach slope

VARIATION IN THE "EMERY" METHOD AND COMPARISON TO INSTRUMENT LEVELLING

As measurement errors using the "Emery" method are cumulative, the inherent inaccuracies of the technique may give results which differ substantially from instrument-levelling. The modified technique, outlined above, was tested for errors and compared to instrument-levelled data on three beach profiles situated on the Atlantic coast of Cape Breton Island, Nova Scotia, Canada (Fig. 2). One profile consisted solely of cobble material thrown up into a storm berm, while the other two consisted of loosely packed, wind-blown or swash-accreted, coarse sand. A profile line was set up normal to shore and surveyed first using a Carl Zeiss level with automatic levelling compensator. Each line was then surveyed five times using the modified Emery method. Height and distances were calculated and plotted for each technique (Fig. 3).

The variance per reading, the cumulative correction for the Earth's horizon, and the mean variation between the Emery and levelling methods at the seaward end of each profile are presented in Table 1. On all profiles the modified Emery method gives a final beach elevation which is greater (1.8-7.1 cm) than that surveyed using instrument levelling. Part of this discrepancy is due to the fact that the landward pole of the frame was placed in a slight depression left by the seaward pole at the previous reading. This positioning should result in a systematic increase in the difference between the two methods down the beach face. As this is not always the case, some of the difference must be due to instrument

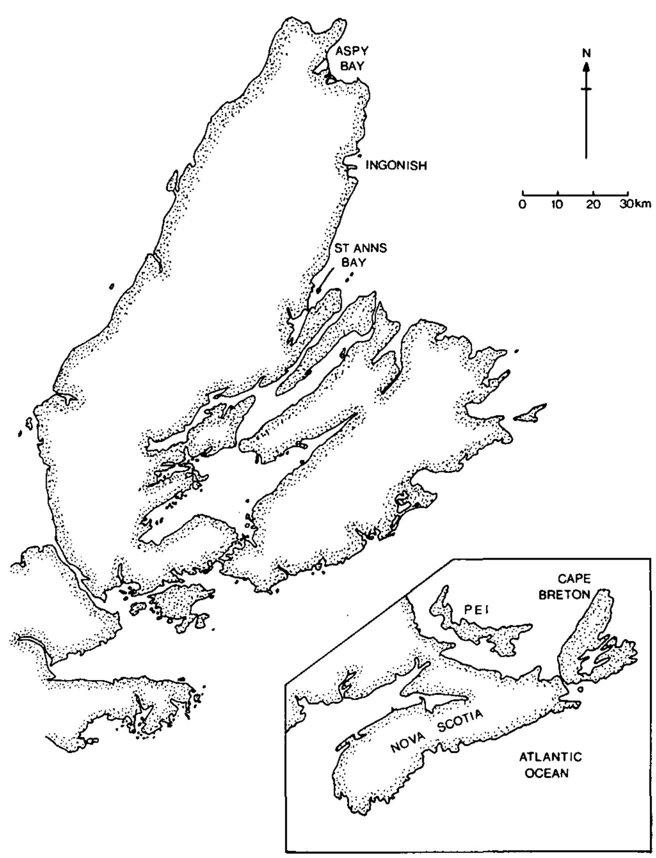

FIG. 2 Beach locations in Nova Scotia for profiles used to evaluate the accuracy of Emery profiling method

TABLE 1: Statistics on Repetitive Profiling (5x) Using Modified Emery Method

	Aspy Bay N.	Ingonish N.	St. Anns Bay
Material	sand	sand	cobble
Average foreshore slope	6.6 degrees	6.1 degrees	7.5 degrees
Variation is slope	0.15 "	0.13 "	0.12 "
Profile length	34.2m	31.3m	23.6m
No. of readings	23	21	16
Cumulative correction due to Earth's curvature	+2.0cm	+3.0cm	+2.2cm
Variation in last reading	6.0cm	12.0cm	7.0cm
Variation/reading	0.26cm	0.57cm	0.44cm
Mean variation between Emery and instrument levelling methods at the end of the profile	-4.6cm	-1.8cm	-7.1cm

resolution for distance. The results also are dependent to some extent on the type of beach material as differences are greater for the cobble beach than for the sand beach. Despite these differences, the resulting profiles constructed using the modified Emery method are indistinguishable in shape from the levelled profiles.

The variation between repeated Emery readings at the end of each profile (6.0-12.0 cm) is greater than both the variation between the modified Emery method and instrument levelling, and the cumulated error due to the Earth's curvature (2.0-3.0 cm). When the profiles are plotted, this variation between repeated readings becomes evident only on Igonish beach. A large part of the error on this latter beach is due to the fact that the surface consisted of either very soft wind-blown or loosely packed swash-deposited sediment. The errors on the other two beaches are similar in magnitude despite different sediments sizes. This variation in the Emery readings is not reflected significantly in foreshore slope calculations. Maximum variation in slope between the 5 profiles surveyed on any beach is only 0.15 degrees. The errors are so small, that areal differences between the repeated profile measurements can be considered insignificant.

COMPUTER PROGRAM

As numerous increments may be needed to survey a complete profile using the modified Emery method, a computer program was written in FORTRAN IV to simplify calculations (Fig. 4). The program requires 26K of core on a CDC 6400 computer and will process data for a single profile in less than one second. The program is based upon the assumption that readings are made consecutively seaward from a benchmark to the waterline. Each profile is identified by a name and date on the first data card. This is followed on the same card by the number of profile readings and by the length of the struts making up the profiling frame. Sequential individual height differences along the profile follow on subsequent cards. The first of these height readings must be a zero, and the second reading must be the benchmark height. As a first step in the program, the uncorrected height of each reading is calculated from the benchmark. These heights are referenced to the waterline and corrected for the Earth's curvature using an iteration technique. At the same time, the true distance and slope between the two poles are calculated. Finally the original readings, slopes, corrected heights and distances are printed out, from the benchmark, for the complete profile.

CONCLUSIONS

A modified profiling scheme is presented for rapid, accurate one-man surveying of beach foreshores. The scheme, modified from Emery (1961), consists of two graded poles levelled relative to each other using the Earth's horizon. The poles are joined together to form a 1.5 x 1.5-m H-shaped frame which can be walked in successive increments down the beach by a single operator. Recording of readings can be facilitated using a tape recorder.

The readings must be corrected for the Earth's curvature. For a 30-m profile sloping 5-7 degrees, this cumulative correction (2-3 cm) is less than the replication error inherent in the system (0.26-0.57-cm/increment). The measurement error of this modified Emery scheme decreases with increased packing of beach sediment. Results appear to be independent of the size of beach sediment. Despite these errors, the resulting data plot closely to

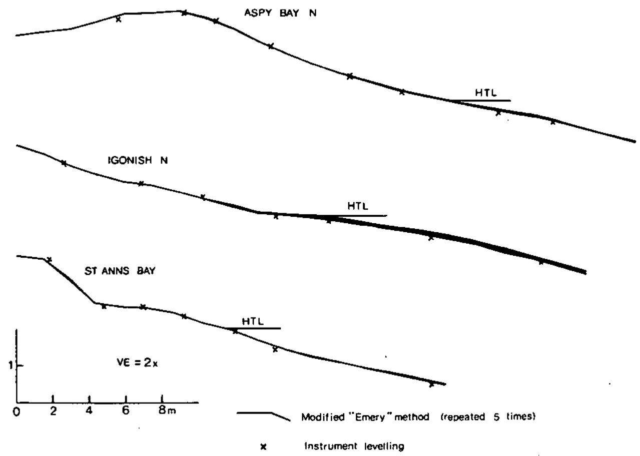

FIG. 3 Profiles illustrating the variation in the Emery method and comparison to instrument levelling

data measured using levelling instruments. Areal differences between profiles measured by these two methods are small. The modified Emery method offers a quick means of surveying beach profiles, produces profiles which have the same slope and shape as levelled ones, and has the added advantage of requiring only one operator.

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Jim Neale, Australian National University, constructed the original modified Emery poles. Bill Cooper of the Bedford Institute of Oceanography aided with some of the testing of replication accuracy. The manuscript was read critically by Dr. Lionel Carter and Dr. Gerry Reinson.

REFERENCES

Emery, K.O. 1961. A simple method of measuring beach profiles; Limnology and Oceanography, vol. 6, pp. 90-93.

Harrison, W. and Boon, J.D. 1972. Beach-water-table and beach-profile measuring equipment, Shore and Beach vol. 40, p. 26-33.

Pitty, A.F. 1968. A simple device for the field measurement of hillslopes. Journal of Geology, vol. 75, no. 6, pp. 717-720.

Riley, S.J. 1969. A simplified levelling instrument: the A-frame; Earth Science Journal vol. 3, no. 1, pp. 51-53.

Schwartz, M.L. 1966. Beach profile translation: scale of shore erosion, Ph.D. Dept. Geol., Columbian Univ. 126 pp.

Stephen, W.J. 1977. A one man profiling method for beach studies; Journal of Sedimentary Petrology, vol. 47, no. 2, pp. 860-863.

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      PROGRAM EMERY(INPUT,OUTPUT,TAPE5,TAPE6)
C     PROGRAM MODIFIED EMERY PROFILE METHOD
C     BASED UPON EMERY (1961) LIMN. AND OCEAN  V. 6 P. 90-93
C     FIRST CARD          --PROFILE NO.          A10
C                         --DATE                 A10
C                         --NO. OF READINGS      I5
C                         --LENGTH OF STRUTS     F5.2
C     SUBSEQUENT CARDS    --HEIGHT CHANGES    16F5.1
C                            IN CM.
C                           FIRST READING  = 0.0
C                           SECOND READING = BENCHMARK HEIGHT
C                           READINGS MUST BEGIN AT LANDWARD END
C
      DIMENSION H(200),D(200),BUF(200),A(200)
      DATA D(1),D(2),BUF(1),H(1),R /4*0.0,6371229.0/
C
C     READ IN DATA
C
    1 READ(5,30) PROFIL,DATE,KO,FKP
      IF(EOF(5))2,3
    3 IF(KO.GT.2..)STOP
      READ(5,31) (H(J),J=1,KO)
   30 FORMAT(2A10,I5,F5.2)
   31 FORMAT(16F5.1)
C
C     INITIALIZE DATA AND BEGIN CALCULATIONS AT THE OCEAN
C
      DO  10 JJ=2,KO
      BUF(JJ)=H(JJ)
   10 H(JJ)=H(JJ-1)+H(JJ)/100.
      DO 11 K=1,KO
      M=KO-K+1
   11 A(K)=H(M)-H(KO)
C
C     CORRECT HEIGHTS FOR EARTH'S CURVATURE
C     ITERATE DISTANCE BETWEEN EMERY POLES
C
      OPB=0.0
      DO 12 J=2,KO
      A(J)=A(J)+OPB
      M=KO-J+2
      DTEST=FKP
      IF(J.GE.KO) GO TO 12
      IF(A(J).LT.A(J-1)) ARG=R/(R+1.5+A(J))
      IF(A(J).GE.A(J-1)) ARG=R/(R+1.5+A(J-1))
      ANGP=ASIN(ARG)
      S=A(J)-A(J-1)
      DO 13 JJ=1,50
      OPP=DTEST/TAN(ANGP)
      IF(S.LT.0.0) OPP=0.0-OPP
      DTEST1=(FKP*FKP-(ABS(S)+OPP)*(ABS(S)+OPP))**0.5
      IF(DTEST-DTEST1.LT.0.0001) GO TO 14
      DTEST=DTEST1
   13 CONTINUE
   14 OPB=OPB+OPP
      A(J)=A(J)+OPP
      D(M)=DTEST1
   12 CONTINUE
C
C     WRITE SLOPE,HEIGHT AND DISTANCE BEGINNING AT BENCHMARK
C
      S=0.0
      WRITE(6,32) PROFIL,DATE
      DO 15 K=1,KO
      M=KO-K+1
      H(K)=A(M)-A(KO)
      IF(K.LE.2) GO TO 15
      D(K)=D(K-1)+D(K)
      S=(H(K-1)-H(K))/(D(K)-D(K-1))
      S=ATAN(S)*57.29578
   15 WRITE(6,33) BUF(K),S,H(K),D(K)
   32 FORMAT(1H1,8HPROFILE-,A10/1X,5HDATE-,3X,A10/
     1 1X,17HEMERY POLE METHOD/
     2 6X,6HHEIGHT,4X,5HSLOPE,4X,6HHEIGHT,3X,8HDISTANCE/)
   33 FORMAT(1H ,F10.0,3F10.3)
      GO TO 1
    2 STOP
      END
```

FIG. 4 Computer program for calculating profiles using the modified Emery method