A method to calculate the accumulated volume of transported masses

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ABSTRACT

Investigation of the depositional environment of fan-deltas might involve some quantative measurements. This program written in Fortran-77 may provide an initial step. This particular volume calculation method is based on cone shaped bodies or derivative shapes. Fans have (in their underwater formation) in plan similar shapes: although in section they are more «flat cone» shaped. This fact however has only a minor influence on the total result.

Key words: calculation method, volume, transported masses, computer program, Fortran-77.

RESUMEN

La investigación del ambiente sedimentario de los fan deltas debe incorporar medidas cuantitativas. Este programa escrito en Fortran-77 puede proporcionar el primer paso. Este método de cálculo de volúmenes se basa en los cuerpos de forma de cono o derivadas de ellas. Los abanicos tienen (en las zonas

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subacuáticas) formas similares en planta, aunque en sección son más en dorma de cono aplastado. Sin embargo, este hecho tiene poca influencia en el resultado final.

Palabras clave: método de cálculo, volumen, masas transportadas, programa de ordenador, Fortran-77.

INTRODUCTION

This method was originally used for sand balance calculations at the coastal dunes of the North Sea. In investigating the relative very short formation time of the barriers and dunes it is an absolute necessity to calculate their volume (Pool & van der Valk, 1988, Postma & Kroon, 1986).

It is a continuous proces governed by periferal and climatic conditions (Jelgersma *et al.*, 1970; Zagwijn, 1984; Short, 1987). The volume calculation method is based on the principle that the masses have cone shaped bodies or derivative formes from these cones. This is why volume calculation using the «grid method» is not favourable due to the many corrections to be made afterwards. Fans have (in their underwater formation) in plan similar shapes; although in section they are more «flat cone» shaped. It might be a good idea to incorporate quantative measurements in the investigation of the depositional environment of fan-deltas. If so, this program written in Fortran-77 might provide the initial step. The author is aware of the fact that going from dune forms to submarine delta forms may involve some corrections in the original program, however it will not change the overall program setup.

DESCRIPTION OF THE PROGRAM

This Area-depth program sums all areas per contourheight and transforms it to one circular area. Next to this operation the volume between two successive concentric contourheights is calculated using the truncated cone formula. One can imagine that it needs error calculation to get an idea about the confidence level of the obtained results. This error calculation may be approximated with the aid of figures 1 to 6. Figure 1 shows the volume formula of a rotated body. Due to the difficulty of obtaining a correct definition of the function $x=f(z)$ it will be to time consuming to use this method. The truncated cone is depicted in figure 2. Differences between both bodies are schematically shown in figure 3. When we suppose that the digitizing of the contours is correct performed, the deviations of the volume calculation result from two items:

1: The summing of all areas with the same contour height to one circular area.

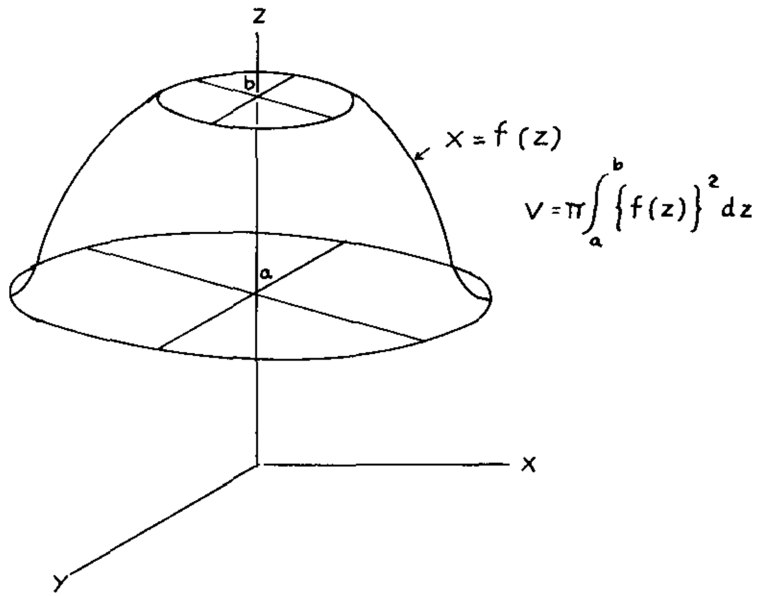

Fig. 1—Volume of rotated body.

Fig. 1—Volumen de un sólido de rotación.

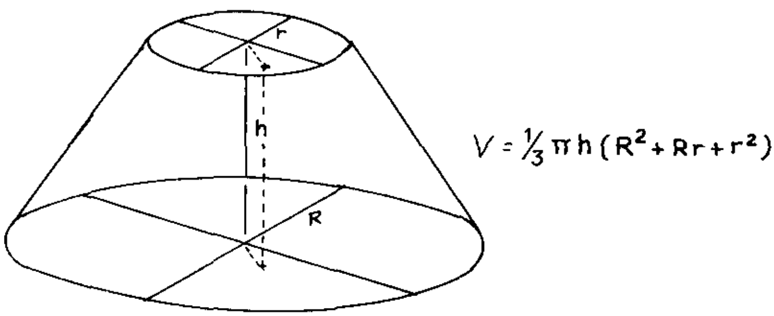

Fig. 2—Truncated cone.

Fig. 2—Cono truncado.

2: The intermediate area; i.e. the area between the contours.

Figure 4 shows how the summing up of all areas with the same contourheight is done. It is important that during digitizing, contour heights of s.c. holes in an contour area are preceeded by a «-» sign. They will automatically be subtracted from the total area. Figure 5 shows a schematic way of visualising the conversion from contours to their equivalent circular section. One can imagine that for each type of underwater deposit a maximum inclination is possible. This maximum inclination angle can serve as an interpolation contour from which the ultimate error calculation can be performed (see figure 6). If digitizing is performed on

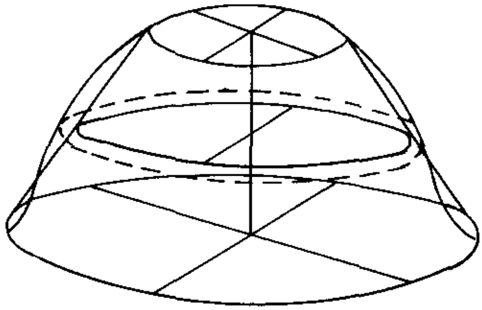

Fig. 3—Composite of figure 1 and 2.
Fig. 3—Figura compuesta de 1 y 2.

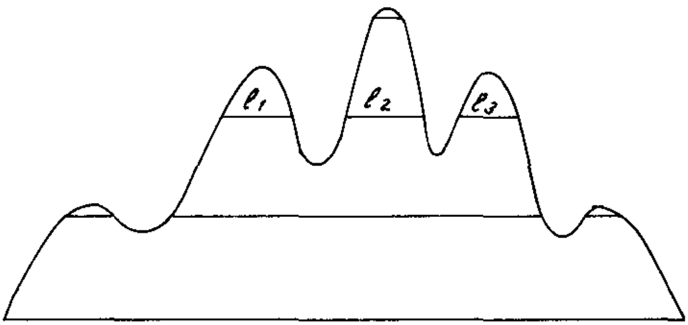

Fig. 4—Schematic section through a body for volume calculation.
Fig. 4— Sección esquemática de un cuerpo para calcular el volumen.

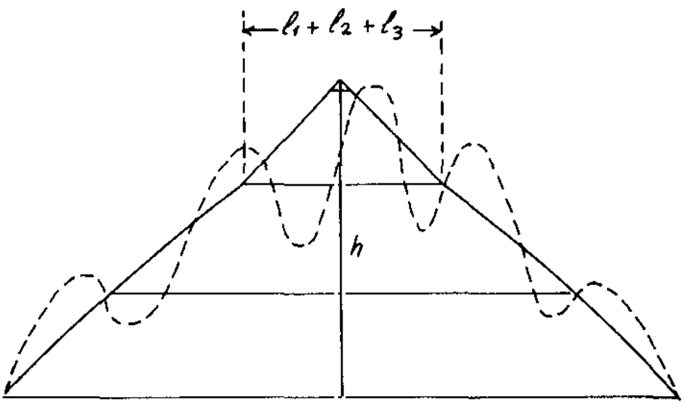

Fig. 5—Schematized truncated cones representing the section of figure 4.
Fig. 5— Conos truncados esquematizados que representan la sección de la figura 4.

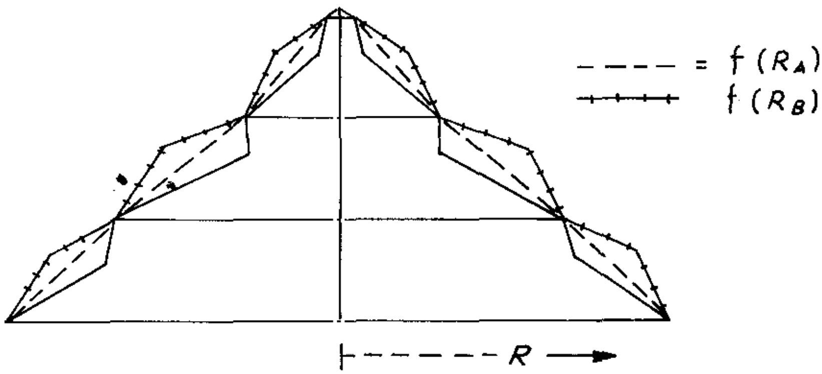

Fig. 6—Correcting with interpolations as used for error calculation.
Fig. 6.—Correción con interpolaciones como se usa para el cálculo de errores.

an accurate basis and the available contourinterval is in a good relation with the area under consideration the error with the areadepth method can be estimated to be in the order of 4-10% of the calculated volume.

Due to the fact that the program «areadepth» expects the digitised data in the format as shown below, a conversion program called «Polygon-format change» is added to this article to make input somewhat easier. The program Areadepth expects the following format:

Every dot represents a position!

```
Filename:                           |.......
Compartment:                        |.......
Project number:                     |.......
Highest point:                      |..........
First Contourheight: (Z-value)      |............
Digitised X- and Y-values:          |...xxxx.x....yyyy.y
Polygon to be closed by:            |.......-1         -1
Second Contourheight:(may be the same)
etc.
Data to be closed by:               |.......0          0
```

An example is shown hereunder.

```
25AN1.DAT
497.5-500/099-104
BP10705
    23.0            (=Highest point)
      20.00000      (=First contour Z-value)
```

```
2253.6     3009.2
2236.5     2952.2
2199.6     2891.6
2155.6     3013.3
2234.3     3010.8
   -1         -1   (Close of Contour)
   10.00000        (Next Z-value)
4609.4     2544.9
4503.7     2512.8
4394.7     2366.7
4610.6     2475.8
4630.0     2544.0
   -1         -1
    5.00000
4953.5     3021.0
4886.2     2928.3
4804.1     2813.1
4829.9     3013.5
   -1         -1
   -5.00000        (Negative; means a "hole" in the contourvalue 5)
1104.6     1442.6
1050.6     1368.6
1030.0     1291.2
1094.5     1350.7
1116.7     1413.1
   -1         -1
     .00010        (This is Contourheight Z=0 !)
4769.9     2664.2
4657.0     2401.9
4130.0     3020.4
4642.8     3020.8
4880.6     3010.6
   -1         -1
    0          0   (End of Data-input)
```

Most digitizing programs (ASCI-format) give other data formats, usually in the form of: X-value...Y-value...Z-value

This is why the following conversion program has to be ran first, the output can then be used for the «Areadepth-program».

PROGRAM POLYGON-FORMAT CHANGE ! -December 1990

```
character*40  line,EINDE*2,OUTFILE,INFILE
```

```
character ZERO*2
 data EINDE /'-1'/
 data zero /'0'/
50   WRITE (*,*)' GEEF NAME INPUTFILE ?'
     READ (*,'(A40)')INFILE
      OPEN (UNIT=20,FILE=INFILE,STATUS='OLD',ERR=50)
     WRITE(*,*)' GIVE NAME OUTPUTFILE ?'
     READ (*,'(A40)')OUTFILE
      OPEN (UNIT=10,FILE=OUTFILE,STATUS='NEW')
     write (*,*)' give filename'
     read (*,'(a40)')line
     write(10,'(a40)')line
     write (*,*)' give compartiment'
     read (*,'(a40)')line
     write(10,'(a40)')line
25    write (*,*)' give highest point'
     read (*,'(I4)',ERR=25)li
     RE=LI*1.
     write(10,'(4X,F4.1)')RE
1     read (20,'(a40)',END=100)line
```

```
c*****Many programs have statements like «End of Polygon, and :Area»
c*****between every digitised polygon.
c***** This is why the if-statements with «P» or «:» or «E» are included.
c*****They have to be customised to the digitise program that is used.
```

```
     if (line(1:1).eq.'E')then
      write (10,'(6x,A2,8x,A2)')EINDE,EINDE
     goto 1
     ENDif
      if (line(1:1).eq.'P'.OR.LINE(1:1).EQ.':')then
     itel=1
     goto 1
     else
     read(line,*)x,y,z
     if(itel.eq.1)then
      write(10,'(6x,f8.5)')z
      write(10,'(3x,f6.1,4x,f6.1)')x,y
     itel=0
     else
      write(10,'(3x,f6.1,4x,f6.1)')x,y
     endif
     ENDIF
     goto 1
```

```
100     WRITE(10,'(6X,A1,8X,A1)')zero,zero
        close (unit=20)
        close (unit=10)
         stop
         end
```

INTERPRETATION AND CONCLUSIONS

Not being a fandelta specialist myself, I hope that this more quantitative (mathematical) approach can be of any help to a better understanding of fandelta formation. As fandeltas can be subdivided into some types, each with different forms and controlled by different processes the question arises if the volume program can be used for all types of fan deltas. The answer can be affirmative (the program uses [converted] rounded polygons) when the contours keep more or less the same shape (not the same size) from top to bottom. A horizontal translation, going downwards along the fan delta is not important, as the calculation of the total volume is performed by the adding of each volume between two contours. Also for flatted cones or sinusoïdal forms, volumes can be quite reliable (within the limits of the general error calculation).

REFERENCES

JELGERSMA, S., JONG, J. de, ZAGWIJN, W. H. & VAN REGTEREN ALTENA, J. F. (1970). The coastal dunes of the western Netherlands: geology, vegetational history, and archeology. *Meded. Rijks. Geol. Dienst NS, The Netherlands*, **21**: 93-167.

POOL, M. A. & VAN DER VALK, L. (1988).*Volumeberekening van het Hollandse en Zeeuwse Jonge Duinzand.* Kustgenese projekt, BP10705 taakgroep 1000. Rijks Geologische Dienst, Haarlem. The Netherlands. 31 pp.

POSTMA, R. & KROON,A (1986). *Mathematische profielanalyse van de onderzeese oever en de aansluitende zeebodem voor de Nederlandse kust.* RWS, Dienst Getijdewateren notitie: GWAO-86.375 The Hague, The Netherlands. 1-45.

SHORT, A. D. (1987). Modes, timing and volume of Holocene cross-shore and aeolian sediment transport, Southern Australia. *In*: N. C. KRAUS (ed.) *Coastal Sediments*, vol II, 1925-1937.

ZAGWIJN, W. H. (1984). The formation of the Younger Dunes on the west coast of the Netherlands (A.D.1000-1600). *Geologie en Mijnbouw*, **63**: 259-268.

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