

Apparent to true dip restoration:
user's manual for the
APP2TRUEDIP software

Version 1.1

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Chapter 1

Purpose, conventions and methods

1.1 Purpose

APP2TRUEDIP computes strike and dip of planar structures measured as two apparent dips along known azimuths. Originally designed for structural measurements on cores from the Ocean Drilling Program (ODP, see Table 1.1 for symbols and acronyms used in this document), it can be used in any situation where two apparent dips are available.

1.2 Structural measurements on ODP cores

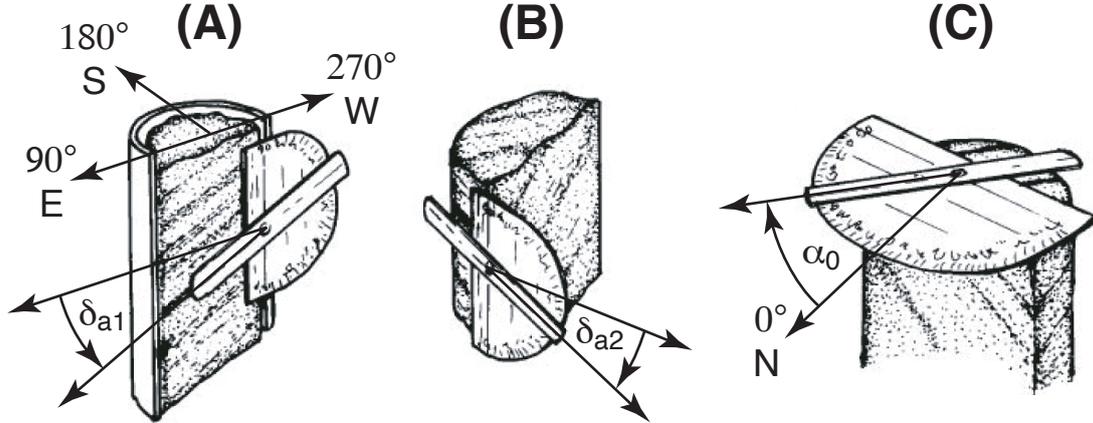
ODP cores are longitudinally split into working and archive halves. This results in two directions along which apparent dips of planar structures can easily be measured : one parallel and the other perpendicular to the cut surface (Figs. 1.1-A and 1.1-B) (*Shipboard Scientific Party, 2003*).

Leg 131 structural geologists defined a conventional local frame of reference attached to these directions (*Shipboard Scientific Party, 1991a*); this frame was also used during leg 134 (*Shipboard Scientific Party, 1992a*).

During leg 135 this frame was rotated by 180° so as to be identical to that used in paleomagnetism (*Shipboard Scientific Party, 1992b*); this new frame has been used henceforth, for examples during legs 140, 147, 153, 176, 180, and 206 (*Shipboard Scientific Party, 1992c, 1993a, 1995, 1999a,b, 2003*), so that the usual convention is (Fig. 1.1-A) :

- the archive half rounded surface faces South (180°) and
- when facing the upright plane cut surface with the top of the core upward, East (90°) is to the left and West (270°) to the right.

A direct strike measurement can also be made when a structure intersects an horizontal section of the core (Fig. 1.1-C).



Archive half core - Top part of the core up

Figure 1.1: ODP core structural measurements on an archive half core piece. The top part of the core is oriented upwards. (A) Conventional reference frame and apparent dip, δ_{a1} , measurement in the East - West vertical plane; (B) Apparent dip, δ_{a2} , measurement in the North - South vertical plane; (S) Strike, α_0 , measurement on an horizontal cut plane. Modified after *Shipboard Scientific Party (1991a, 2003)*.

True dip and dip direction can thus be computed either from two apparent dip measurements along two directions, or from one apparent dip measurement along one direction coupled with a strike measurement.

1.3 Methods

Given a 1st apparent dip, δ_{a1} , along direction, β_{a1} , and a 2nd apparent dip, δ_{a2} , along direction, β_{a2} , true dip, δ_0 , and true dip direction, β_0 , are the two unknowns of the system of two equations :

$$\tan(\delta_{a1}) = \cos(\beta_0 - \beta_{a1})\tan(\delta_0) \quad (1.1)$$

$$\tan(\delta_{a2}) = \cos(\beta_0 - \beta_{a2})\tan(\delta_0) \quad (1.2)$$

The algorithm implemented in APP2TRUEDIP proceeds in three steps :

1. it first validates input (i.e., verifies input format);
2. it then checks whether the system of equations (1.1) and (1.2) falls in the case that yields a single solution;
3. if both above verifications are successful, it finally computes the single solution (δ_0 , β_0).

If input validation fails or if the equation system does not yield a single solution, an explanation is returned.

1.4 Using the program

1.4.1 Input and Output

Input can read

- either from the keyboard,
- or from a text file.

Similarly output can be directed

- either to the screen terminal,
- or to a text file.

When a couple of data need be processed, the programme be run interactively by choosing keyboard input and screen output. Alternatively, output can be directed to a file to keep a record.

Input and output files become more appropriate as the number of data increases. In that case, the program is designed with the idea of easily creating the input file by exporting the relevant data from a typical structural spreadsheet and of creating an output file that can also easily be imported back in the spreadsheet.

When apparent dip measurements are only made along North, East, South and West directions, they may be recorded as N, E, S and W in structural spreadsheets. The [alphanumeric input file](#) format is designed to accomodate this.

Alternatively directions may also be recorded as number in the structural spreadsheet. This allows to include apparent dip measurements along any direction as well as along 0, 90, 180 and 270. The [numerical input file](#) format is designed to accomodate this.

1.4.2 Running the program

The program is designed to run with minimal interaction. It first issues a few queries, then makes the calculations, writes the results, and exits. It thus processes only one file at a time and need to be launched again if another file need to be processed.

Table 1.1: Symbols and acronyms used in this document

Symbol	Comments
DSDP	Deep Sea Drilling Project (1966-1983)
ODP	Ocean Drilling Program (1985-2003); this acronym is used <i>sensu lato</i> in this document to refer to DSDP, ODP and IODP indistinctly
IODP	Integated Ocean Drilling Program (2003-2013) and International Ocean Discovery Program (2013-2024)
α_0	Strike
β_0	True Dip direction
δ_0	True Dip
β_{a1}	Apparent dip direction 1
δ_{a1}	Apparent dip 1 along direction 1
β_{a2}	Apparent dip direction 2
δ_{a2}	Apparent dip 1 along direction 2
N	North
E	East
S	South
W	West

Chapter 2

Input files

2.1 Introduction

APP2TRUEDIP accepts two types of structural measurements input files :

1. **alphanumeric input files** that were designed for core structural measurements made in ODP legs where apparent dip directions were measured along North, East, South, and West conventional directions and labeled by the characters E, W, N, S;
2. **numerical input files** that are made for measurements of apparent dips along any azimuth and where the azimuth is thus given as a number.

This chapter describes the formats of these two data files.

2.2 Common conventions for both types of input files

The input files are [ASCII](#) text files containing space or tab delimited characters or numbers that are read in [FORTRAN free format](#). They can be created in and then exported from spreadsheets or word processors as detailed in section [4.4](#). All character strings need be delimited by single quotes, and further caveats are explained in chapter [4](#).

Both alphanumeric and numerical input files follow a [standard file](#) structure that begins with a [standard header](#) which is followed by [standard data lines](#).

The [standard header](#) contains two lines with a title in the first line and columns headers in the second line. (N.B. Legacy input files for APP2TRUEDIP versions < 3.0 followed the same rules except for a single line header that contained the columns headers only.)

The [data lines](#) formats are different for both types of files and cannot be mixed in the same file. They are described below.

2.3 Alphanumerical input files

Table 2.1: Alphanumerical input data line case 1.

Column ¹	Parameter	Type	units	Range	Comments
1	apparent dip 1	real	degrees]0, 90]	Zero dip not allowed in this column: must be put in column 3
2	azimuth 1	character		'E', 'W' ²	Only E or W azimuths in this column
3	apparent dip 2	character	degrees	[0, 90]	Zero dip allowed here; if along E or W, must be entered as strike instead (case 2)
4	azimuth 2	real		'N', 'S' ²	Only N or S azimuths in this column

¹ Column number refers to spreadsheet columns, i.e., to the tab-separated entries in the text file.

² N, E, S, W are upper case, single character variables delimited by single quotes. N, E, S, W = North, East, South, West.

Table 2.2: Alphanumerical input data line case 2.

Column ¹	Parameter	Type	units	Range	Comments
1	apparent dip 1	real	degrees]0, 90]	Zero dip not allowed in this column: to be entered as strike instead
2	azimuth 1	character		'E', 'W', 'N', 'S' ²	
3	strike	real	degrees	[-360, +360]	
4	strike indicator	character		'A' ³	

¹ Column number refers to spreadsheet columns, i.e., to the tab-separated entries in the text file.

² N, E, S, W are upper case, single character variables delimited by single quotes. N, E, S, W = North, East, South, West.

³ A is an upper case, single character variable delimited by single quotes that designates azimuth of strike.

There are 2 cases for input data lines that correspond to two different couples of measurements :

- case 1: two apparent dips or
- case 2: one apparent dip with one strike direction.

These cases can be mixed at will in the input file.

2.3.1 Alphanumerical data line case 1: two apparent dips

Three rules must be followed :

- E or W apparent dip measurements must be in columns 1 and 2
- S or N apparent dip measurements must be in columns 3 and 4
- 0 dip measurements must not be in columns 1 and 2, but in columns 3 and 4.

Note that, since column 4 does not allow E or W measurements, apparent dip = 0 along these directions cannot be entered in alphanumerical data line case 1 and have to be entered as strike measurements in alphanumerical data line case 2. The alphanumerical data line case 1 is described in Table 2.1.

2.3.2 Alphanumerical data line case 2: one apparent dip with one strike direction

Rules to follow :

- Apparent dip data is given in columns 1 and 2 and can be along E, W, N or S
- Strike is given in column 3 followed by 'A' (for Azimuth) in column 4
- Strike should be chosen so that dip is to the right (if not, it will be corrected)

The alphanumerical data line case 2 is described in Table 2.2.

Table 2.3: Examples of alphanumerical input data lines.

Columns				Comments
1	2	3	4	
16	'E'	50	'S'	OK : case 1
16	'W'	50	'S'	OK : case 1
16	'E'	50	'N'	OK : case 1
16	'W'	50	'N'	OK : case 1
16	'W'	0	'N'	OK : case 1
16	'E'	50	'A'	OK : case 2
16	'W'	230	'A'	OK : case 2
16	'S'	50	'A'	OK : case 2
16	'N'	230	'A'	OK : case 2
50	'S'	270	'A'	OK : case 2 (*)
16	'N'	50	'E'	Faulty case 1 : the E-W data must be first
0	'W'	50	'S'	Faulty case 1 : zero dip data should be entered either second or as strike as in (*)
16	'W'	50	'A'	Faulty case 2 : strike will be corrected to 230

2.3.3 Alphanumerical input examples

Examples of acceptable and erroneous data lines are given in Table 2.3. A sample file is provided as [894G8R1_in1_aln.txt](#) (*Shipboard Scientific Party, 1993b*)

2.4 Numerical input files

2.4.1 Numerical data line

Only one restriction must be followed :

- 0 dip measurements must not be in columns 1 and 2, but in columns 3 and 4.

The numerical data line is described in Table 2.4.

Table 2.4: Numerical input data line.

Column ¹	Parameter	Type	units	Range	Comments
1	apparent dip 1	real	degrees]0, 90]	Zero dip not allowed in this column: to be entered in column 3 instead
2	azimuth 1	real	degrees	[-360, +360]	
3	apparent dip 2	real	degrees	[0, 90]	
4	azimuth 2	real	degrees	[-360, +360]	

¹ Column number refers to spreadsheet columns, i.e., to the tab-separated entries in the text file.

2.4.2 Numerical input examples

Examples of acceptable and erroneous data lines are given in Table 2.5. A sample file is provided as [1109D47R2_in1_num.txt](#) (*Shipboard Scientific Party, 1999c*).

Table 2.5: Examples of numerical input data lines.

Columns				Comments
1	2	3	4	
16	90	50	180	OK : two apparent dips
16	270	50	180	OK : two apparent dips
16	90	50	0	OK : two apparent dips
16	270	50	0	OK : two apparent dips
16	270	0	0	OK : one apparent dip and one strike
0	270	50	180	Faulty two apparent dips : zero dip data should be entered second

Chapter 3

Output files

3.1 Introduction

APP2TRUEDIP generates two types of output files :

1. **alphanumerical output files** when the input file is alphanumerical;
2. **numerical output files** when the input file is numerical.

This chapter describes the formats of these two output files.

3.2 Common conventions for both types of output files

The output files are [ASCII](#) text files containing tab delimited characters and numbers so as to facilitate importing the results into a structural spreadsheet. Character strings are delimited by single quotes so that the output file can also be used as input file for APP2TRUEDIP.

Both alphanumerical and numerical input files follow a [standard file](#) structure that begins with a [standard header](#) which is followed by [standard data lines](#).

The [standard header](#) contains two lines with a title in the first line and columns headers in the second line. (N.B. Legacy input files for APP2TRUEDIP versions < 3.0 followed the same rules except for a single line header that contained the columns headers only.)

The [data lines](#) contains 7 columns in both types of files :

- Columns 1 to 4 repeat the input data in the same format as in the input file,
- Columns 5 and 6 contain the results of the restoration : strike and true dip,
- Column 7 contains comments.

Further Specifications are given below.

3.3 Alphanumerical output files

Table 3.1: Alphanumerical output data line case 1.

Column ¹	Parameter	Type	units	Range
1	apparent dip 1	real	degrees]0, 90]
2	azimuth 1	character		'E', 'W' ²
3	apparent dip 2	real	degrees	[0, 90]
4	azimuth 2	character		'N', 'S' ²
5	strike ³	real	degrees	[0, +360]
6	true dip	real	degrees	[0, 90]
7	comments ⁴	character		

¹ Column number refers to spreadsheet columns, i.e., to the tab-separated entries in the text file.

² N, E, S, W = North, East, South, West.

³ Such that dip is to the right.

⁴ Eventual explanation of the input data problem that precluded computation.

Table 3.2: Alphanumerical output data line case 2.

Column ¹	Parameter	Type	units	Range
1	apparent dip 1	real	degrees]0, 90]
2	azimuth 1	character		'E', 'W', 'N', 'S' ²
3	strike ³	real	degrees	[-360, +360]
4	strike indicator	character		'A' ⁴
5	strike ⁵	real	degrees	[0, +360]
6	true dip	real	degrees	[0, 90]
7	comments ⁶	character		

¹ Column number refers to spreadsheet columns, i.e., to the tab-separated entries in the text file.

² N, E, S, W = North, East, South, West.

³ Eventually corrected so that dip is to the right.

⁴ A indicates that azimuth is for strike.

⁵ Such that dip is to the right.

⁶ Eventual explanation of the input data problem that precluded computation.

There are 2 formats for output data lines that correspond to the two different input couples of measurements :

1. two apparent dips or

2. one apparent dip with one strike direction.

3.3.1 Alphanumerical data line case 1: two apparent dips input

The alphanumerical output data line case 1 is described in Table 3.1.

3.3.2 Alphanumerical data line case 2: one apparent dip with one strike direction input

The alphanumerical output data line case 2 is described in Table 3.2.

3.3.3 Alphanumerical output examples

A sample file is provided as [894G8R1_out1_aln.txt](#).

3.4 Numerical output files

The numerical data line is described in Table 3.3.

Table 3.3: Numerical output data line.

Column ¹	Parameter	Type	units	Range
1	apparent dip 1	real	degrees]0, 90]
2	azimuth 1	real	degrees	[-360, +360]
3	apparent dip 2	real	degrees	[0, 90]
4	azimuth 2	real	degrees	[-360, +360]
5	strike ²	real	degrees	[0, +360]
6	true dip	real	degrees	[0, 90]
7	comments ³	character		

¹ Column number refers to spreadsheet columns, i.e., to the tab-separated entries in the text file.

² Such that dip is to the right.

³ Eventual explanation of the input data problem that precluded computation.

3.4.1 Numerical output examples

A sample file is provided as [1109D47R2_out1_num.txt](#).

Chapter 4

Data files: general requirements

4.1 Introduction

This chapter describes a few common attributes of data files used by the APP2TRUEDIP program.

4.2 Fortran input/output conventions

APP2TRUEDIP is developed in FORTRAN and uses FORTRAN sequential input and output text files.

- The input/output files are ASCII files, i.e. plain text files without accentuated characters. If input files are prepared within a software other than a pure [text editor](#), such as a word processor or a spreadsheet, they need be exported as text only files.
- During input, each reading statement normally focusses on one input line with the following conventions:
 - If all the data to be read within a line are found, the rest of the line is not read. The next input statement will seek its data in the next line. This implies that extra information can be added AFTER the required data without affecting the input.
 - If all the data to be read are not found within a line, the missing data will be sought in the next line. This implies that an incomplete line will be completed by the probably misinterpreted next line.
- There are two possible formats for FORTRAN sequential input files: free or fixed formats. APP2TRUEDIP uses free format input files.

4.2.1 Fortran free format

- Reading rules
 - Data are separated by empty spaces or tabulations (more suited for spreadsheet).
 - Character strings MUST be delimited by single quotes, ', to be read properly.
- Possible file preparation
 - In a text editor or spreadsheet and saved as text only.
 - Tab separated text output is most convenient, as it is easy to read and can also be opened in a spreadsheet.

4.3 Operating system issues

4.3.1 Encoding

Text encoding systems that are compatible with [ASCII](#) should work. On MacOS X both Mac OS Roman and UTF-8 work.

4.3.2 End of line

The special character used to mark the end of line (EOL) in the input file must be consistent with the system used to run APP2TRUEDIP ([Table 4.1](#)). If the end of line is

Table 4.1: End of line (EOL) coding in common operating systems.

Operating system	EOL symbol	EOL description
MacOS X	LF	Line Feed
Unix	LF	Line Feed
Windows	CRLF	Carriage Return + Line Feed
MacOS Classic	CR	Carriage Return

not recognized, the whole input file may appear as a single line to the program. Problems tend to arise when the file is transferred from one operating system to another, or when the file is exported from a word processor or spreadsheet. If ftp is used between systems, setting text, instead of binary, transfer of data files should translate the end of line.

It is therefore recommended to use a [text editor](#) to check, and eventually correct, end of line characteristics of data files that have been exchanged between systems or that have been exported from a word processor or a spreadsheet.

4.3.3 End of file

- Always terminate the file with an empty line (extra line with no space). This avoids putting the end of file (EOF) tag in the last data line. In some systems, including MacOS X, such a situation can result in the last data line not being read.
- Always check that the number of data stored in the program is exactly the expected number of data. If one datum is missing, the above most likely applies.

4.4 Creating input files

Data files can be created with a [text editor](#) (recommended) or a [word processor](#). [Free format](#) data files can also be created with a [spreadsheet](#).

4.4.1 Text editors

Preparing an input file with a text editor has the advantage of directly creating a plain text file. There are then only two issues to deal with when saving the file:

1. check and eventually modify [end of line](#) coding, and
2. make sure the [end of file](#) is below the last data line.

Here is a list of text editors that allow to check and alter end of line and text encoding of text files:

- under MacOS X: [TextWrangler](#), [BBEdit](#), [Smultron](#), and [Plain Text Editor](#);
- under Windows: [ConTEXT](#).

4.4.2 Spreadsheets

Input files that are read in [free format](#) can be prepared with a spreadsheet. There are then four issues to deal with:

1. exporting the file as tab delimited text,
2. making sure that character strings are enclosed within quotes for [free format](#) files,
3. checking and eventually correcting [end of line](#) coding, and
4. making sure the [end of file](#) is below the last data line.

The last three issues are best dealt with by importing the file in a [text editor](#).

4.4.3 Word processors

Finally, input files can also be prepared with a word processor. Three issues must be dealt with:

1. exporting the file in plain text (tab delimited columns recommended),
2. checking and eventually correcting [end of line](#) coding, and
3. making sure the [end of file](#) is below the last data line.

Again, the last two issues are best dealt with by importing the file in a [text editor](#).

4.5 Standard input/output files

APP2TRUEDIP uses a file format that was designed to be easily exchanged with [spreadsheets](#) and that is called 'standard files' in what follows.

4.5.1 Standard file structure

- Data files are [ASCII](#) files.
- They are made of a header followed by data lines.

4.5.2 Standard header

The standard header is made of two lines:

1. Title line: the first line contains the title.
2. Columns headers line: the second line contains the columns headers

The standard header is read in [free format](#): title and column headers are character strings and need be delimited by single quotes ', so as to be read properly.

4.5.3 Standard data line

- All parameters for each datum are given in a single data line.
- Data line are read in [free format](#). Parameters may be separated by empty spaces or tabs. Character strings need be delimited by single quotes '.

4.5.4 Standard file example

Example of a standard data file with 2 reals, 1 integer and 1 character string per data. Here are the 3 first lines of the file with two header lines and the first data line:

1. 'Title'
2. 'Parameter-1' 'Parameter-2' 'Parameter-3' 'Parameter-4'
3. 12000.6 2999.4567 245 'label-of-data1'

Chapter 5

How to refer to App2truedip and relevant references

5.1 How to refer to App2truedip

If you publish results obtained with APP2TRUEDIP, it would be appreciated that you referred to:

- the software version and its location as:
Celerier, B., YYYY, APP2TRUEDIP: Apparent to true dip restoration software, version XX.X,
<http://www.celerier.gm.univ-montp2.fr/software/dcmt/app2truedip/app2truedip.html>.
where XX.X and YYYY are the version and year of the software used that are displayed in the console when the program starts and terminates.

5.2 Other relevant references

- Early ODP conventions for structural measurements in boreholes with reference frame different from that in paleomagnetism : *Shipboard Scientific Party* (1991a, 1992a).
- Usual ODP conventions for structural measurements in boreholes with same reference frame as that for paleomagnetism : *Shipboard Scientific Party* (1992b,c, 1993a, 1995, 1999a,b, 2003).
- Core structures reoriented with paleomagnetism : *Shipboard Scientific Party* (1991b); *Lallemant et al.* (1993).
- Core structures reoriented with imaging logs : *MacLeod et al.* (1992); *MacLeod and Pratt* (1994).

Chapter 6

App2truedip revision history

6.1 App2truedip versions history

APP2TRUEDIP was originally designed in summer 1997 to restore strike and dip of planar structures measured as two apparent dips on ODP Leg 176 cores. These apparent dips were measured along North, East, South, and West conventional directions and labeled by the characters E, W, N, S. A new input file format with numerical azimuth that allows to take into account non perpendicular apparent dip measurements was added during Leg 180 in summer 1998. Originally developed on MacOS Classic, it was ported to SUNOS workstations, and to MacOS X. Version history is summarized in Table 6.1.

Table 6.1: APP2TRUEDIP program versions

Version	Date	Comments
4.1	6 March 2025	Add run information in output header, revise menus and terminal output, f90.
4.0	28 August 2022	Upgraded libraries.
3.2	1 January 2018	Upgraded libraries.
3.1	17 May 2012	Upgraded libraries.
3.0	17 May 2012	Standard file header, upgraded libraries, last MacOS Classic version.
2.2	16 May 2012	Tidy up source code.
2.1	10 November 2004	Allows input from file or keyborad, output to file or screen; MacOS X version.
2.0	22 June 1998	Add numerical input format.
1.0	30 July 1997	Alphanumerical input format only.

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