Bureau of Mineral Resources, Geology & Geophysics

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STRUCTURAL GEOLOGY INFORMATION:

COLLECTION TECHNIQUES AND DATA TRANSFER

BETWEEN

DG-ORACLE and ARC/INFO

by

P.R. WILLIAMS

A contribution to the National Geoscience Mapping Accord
EASTERN GOLDFIELDS PROJECT

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ABSTRACT

A prototype method for transferring symbology (eg a symbol for the strike and dip of a rock cleavage) or other vector data from the BMR corporate ORACLE database to the Mineral and Land Use ARC/INFO GIS provides a means for the rapid, automated plotting of field structural geology data onto geological "compilation" map sheets, and ultimately published maps. The flow chart established for the handling of field structural data provides a model applicable to all Mapping Accord projects.

INTRODUCTION

Attribute data normally plotted on geological maps is not generally conveniently plotted by automatic means. Symbol generation software is costly and usually has a limited and fixed number of symbol forms or fonts. The fonts for annotating the symbols are not readily transferable between different software packages.

Attribute data of this type - particularly azimuth and inclination information relating to rock structural and fabric elements - should only be handled once, and thereafter be available to any number of software packages for manipulation and analysis.

This contribution describes the methods developed on the Eastern Goldfields project to achieve this result for the hardware and software packages used by the Minerals and Land Use Program.

DATA ENTRY

Once structural and sample information is collected in the field, geologists are required to store this information on a disk file by using a portable computer. This work is generally carried out either in the evening or at the weekend following completion of a traverse. Two programs are available in IBM-compatible format for this, SAMP and STRUC. Although alternative programs could be used for data entry (eg spread sheets or commercial databases), use of SAMP and STRUC are cheap (free) and ensure that all necessary data is added and that codes used in the ORACLE database for recognising the type of structure being entered are correct.

SAMP and STRUC produce output which can be downloaded directly into the STRUCTURAL GEOLOGY database and SAMPLES table of the PETCHEM database (Fig.1).

Thus at the end of field operations, all sample and structural data is in a digital form suitable for immediate storage in the BMR corporate database (Fig.2).

POSITION INFORMATION

Data produced by STRUC in the form shown in Figure 1 require positional information before they can be plotted onto geological maps. All sample and structural localities have to be given an AMG grid reference or a latitude and longitude position. This may be achieved by one of three main techniques:

1. From base map grids. This requires that locality positions be transferred from 'photo overlays to a gridded topographic base, grid references read off, and full grid values entered manually.

2. From base maps using a digitiser. This requires that locality positions be plotted onto a base map which contains at least two and preferrably four or more points with known AMG or geographic coordinates.

3. From a global positioning system which can record and store AMG/geographic coordinates for each location visited.

Of these methods, method 3 would be ideal if complete daytime satellite coverage was available, as it is error-free, except for incorrect keying of location numbers. Method 1 is very error-prone due to the manual calculation and manual entry techniques employed. Currently, method 2 is the most widely available and least susceptible to error - digitiser error is negligible and keying of location identifiers is kept to a minimum. Minerals and Land Use have two main programs for accepting digitiser data:

1. DIGitise GRid reference (Fig.3) - produces an output file suitable for immediate down-loading to the BMR LOCALITIES database. This file can be used with another program, GRID2LL which calculates the geographic coordinates of data points from the digitised grid references, using a subroutine provided by T.Luyendyk (airborne geophysics).
2. ARC/INFO - produces an ARC/INFO point coverage of locality information which can be exported to an ASCII file for loading into the ORACLE LOCALITIES table.

STRUCTURAL GEOLOGY DATABASE

The structural geology database has been described by Williams (1989), Collins(1990) and Williams and Ryburn (1991). The database is fully relational, versatile and expandable. It was designed to provide the basis for a comprehensive plotting package and to be available to GIS applications. Plotting of information held in the database is currently possible on the ZETA plotter through MAPDAT (Collins, 1990).

Structures are identified within the database by their type and subtype. For example, bedding is a type (type 1) which has many subtypes, such as overturned (subtype 21). Planar surfaces may contain lineations recorded as pitch and direction of pitch, or lineations may be recorded separately (types 20-29). Each symbol identified in the BMR symbols book (BMR, 1989) must have a unique type/subtype combination. The information required to produce the structural symbols is stored in the ORACLE STRUCTYPES table (see Collins, 1990; Williams and Ryburn, 1991); thus users may generate their own special symbols as desired, without any need to alter and recompile the plotting or transfer software.

The STRUCTURAL GEOLOGY DATABASE comprises three ORACLE tables, reviewed briefly here.

1. STRUCTURES table.
This contains the following information

a) Location number
b) Structure type
c) Structure subtype
d) Direction of dip (azimuth)
e) Dip/plunge
f) Pitch
g) Direction of pitch (octant)
h) Priority (defines a plot priority)

2. STRUCTYPES (Structure types) table.
This contains details of the structures

a) Structure type
b) Structure subtype
c) Legend
d) Description
e) Symbol (a coordinate string defining the plot symbol)
f) Endpoint (where the dip/plunge number will be plotted)

3. LOCALITIES table
This table contains a variety of information including

a) Location number

b) Easting in meters
c) Northing in meters
d) 1:100 000 map name
e) 1:100 000 map number
f) Latitude
g) Longitude

Thus to make a selection from the database requires joining three tables on three items (location name, stucture type, structure subtype). Several SQL batch files are available to achieve this.

TRANSFERRING DATA FROM ORACLE TO ARC/INFO

The development of the program "O2A" (Oracle to Arc) provides the link necessary to the ARC/INFO package, allowing the automatic addition of data held in the database to an ARC/INFO map coverage.

O2A is a FORTRAN 77 program which runs on the BMR Data General computer under AOS/VS. Subroutines used for plotting were written by D. Downie and symbol-string routines by D. Collins, both of Information Systems Branch. O2A reads data from a formatted ASCII file produced by ORACLE from an SQL batch file (Fig. 4). The select statement in this file must be modified to suit user requirements. The file shown in Figure 4 selects all priority 1 cleavage readings from the Leonora 1:100 000 map sheet.

O2A produces two output files, a "symbols" file and an "annotations" file. ARC/INFO will import the symbols for each structural reading as a series of arcs (Fig. 5). Each structural symbol is generated to the size required by the user, but defaults to the standard BMR sizes specified in the BMR symbols book (BMR, 1989). These files contains output suitable for immediate import into ARC/INFO using the "GENERATE" command. See the ARC/INFO manuals for use of this import facility.

SYMBOLS FILE:
The symbols are imported as a group of vectors, or arcs, and cannot therefore be easily manipulated in ARC/INFO as a single entity. Thus size, for instance, needs to be generated by the export program, and cannot be changed as a group within ARC/INFO. Editing and moving symbols can be tedious if the symbols are made up of more than one arc.

ANNOTATIONS FILE:
The annotations file contains all text data which needs to be plotted along with the line symbols. The data are stored as text strings, and not vectors, and can therefore be plotted in ARC/INFO with any font, size or colour independent of the information contained in the text. They can also be manipulated in a straight-forward manner with the ARC/INFO package (eg moved and rotated).

SAMPLE TRANSFER SESSION

This section shows a typical set of instructions needed to select data from ORACLE, and transfer that data to ARC/INFO, assuming the user is operating on a PC connected to the Sytek LAN running CEO CONNECTION. Key strokes are enclosed in <angular brackets>.

STEP 1: Logon to the Data General using <CEO> and your user name.

STEP 2: Run <SLATE O2A.SQL>
This will give you an editing session for the SQL batch file needed to select the correct data. Change the selection criteria to suit your ARC/INFO coverage requirement. Do not change the table joins in the select statement.

STEP 3: Exit SLATE (<F1> <bye>)

STEP 4: <SQLplus> to commence operation of the structural geology database. Logon with you ORACLE user

code and password at the appropriate prompts.

STEP 5: <START O2A> This runs the batch file to select the appropriate data from the database.

STEP 6: At the first prompt, enter the file name to which the data is to be written. (eg EXAMPLE.CLV).

STEP 7: <BYE> to exit from ORACLE.

STEP 8: <x o2a> runs the conversion program. This program will prompt for three file names.
Input File : Same name as in step 6
Symbols file : eg. <EXAMPLE.CLV.SYMB>
Annotations file : eg. <EXAMPLE.CLV.ANNO>

STEP 9: <CONTROL><BREAK> to return you to local PC mode

STEP 10: Choose the receive file option from the CEO CONNECTION menu.

STEP 11: Using the /T=TXT option transfer the symbols and annotations file to a 3.5" floppy disk on your PC.

STEP 12: Using either the remote sensing PC configured for NFS or the SUN IPC workstation configured to DOS, transfer the files to the SUN network into your own work space

STEP 13: Run ARC on the SUN network and use "GENERATE" to import both the symbol vector strings and the annotations to the same cover.

STEP 14: The ARC commands for creating the cover are as follows:

```
ARC: <GENERATE> <COVER_STRUCTURES>
GENERATE: <INPUT> <EXAMPLE.SYM>
GENERATE: <LINES>
GENERATE: <INPUT> <EXAMPLE.ANN>
GENERATE: <ANNOTATION> <0 0>
GENERATE: <QUIT>
```

REFERENCES

Collins, D. 1990. MAPDAT: A program for plotting spatial data from a relational database onto maps. Bureau of Mineral Resources Record 1990/79.

Williams, P.R., Ryburn, R.J. and Collins, D. 1989. Structural Geology Database. *In* Geoscience Mapping towards the 21st Century. 1989 BMR Research Symposium Extended Abstracts.

Williams, P.R. and Ryburn, R.J. 1991. A Guide to the Structural Geology Database. In preparation.

FIGURE CAPTIONS

Figure 1A

structures username/password

```
!origno locno type subtype azimuth inclin pitch octant  generat
   *- *--------- *- *- *-- *- *- *- *
3340 53 90963002   2  2  75 90
3340 53 90963002  21  4 340 10
3340 53 90963002   2 11  85 30      3
3340 53 90963002   2  1 305 88
3340 53 90963003   2  2 150 90
3340 53 90963004   2  1 240 60
3340 53 90963004   2  2  80 90
3340 53 90963005   1 21  65 82      0
3340 53 90963005   2  1  65 82      1
3340 53 90963005   2  1  90 90
3340 53 90963006   1  1  70 74      0
3340 53 90963006   2  1  70 74      1
3340 53 90963006   2  2 100 90      2
```

samples username/password

```
!gridref sampno origno mapno fieldno lithology
*--------- *---------- *- *--- *--------- *----------------------------------------------------------------
48232472  90963009     53 3340 90963009  Felsic agglomerate
49002265  90963014     53 3340 90963014  Feldspar phyric crystal tuff
46951817  90963047A    53 3340 90963047  Contact metamorphic siltstone
46951817  90963047B    53 3340 90963047  Feldspar phyric andesite sill
46292134  90963052     53 3340 90963052  ? Andesite intrusive
5119815360 90963065A    53 3340 90963065  Flattened ovoids in cherty sandst
5119815360 90963065B    53 3340 90963065  Breccia
49591202  90963066A    53 3340 90963066  Siltstone
49591202  90963066B    53 3340 90963066  Siltstone
49591202  90963066C    53 3340 90963066  Isoclinal fold in siltstone
47421237  90963069     53 3340 90963069  Folded BIF
```

Figure 1:

The form of the structural (1A) and sample (1B) data at the end of field operations.

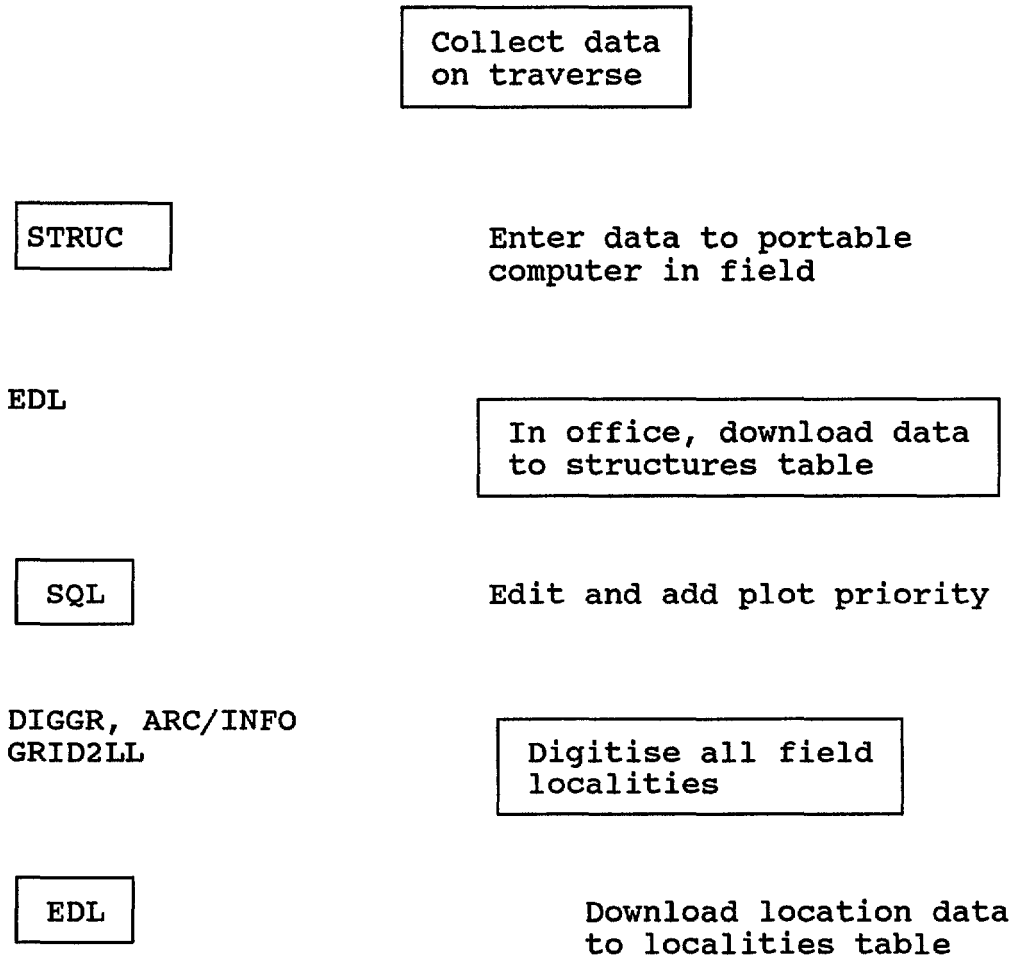

Figure 2:
Flow chart showing commands for field data entry and downloading to the BMR ORACLE database.

Figure 3A

MINERIE	Exact values	
89963039	381637	6814726
89963040	383764	6815132
89963041	383364	6814773
89963042	383813	6817081
89963043	385850	6815162
88PW490	383598	6815955
88PW491	383320	6815996

Figure 3B

```
121.787276 28.789458 381637. 6814726. 89963039
121.809107 28.785988 383764. 6815132. 89963040
121.804972 28.789191 383364. 6814773. 89963041
121.809808 28.768404 383813. 6817081. 89963042
121.830478 28.785904 385850. 6815162. 89963043
121.807491 28.778546 383598. 6815955. 88PW490
121.804647 28.778151 383320. 6815996. 88PW491
```

Figure 3:

A) DIGGR - output format.
B) Format following processing through GRID2LL.

```
SPOOL &1;
SET PAGESIZE 50000;
SET LINESIZE 72;
SET LONG 512;
COLUMN SYMBOL FORMAT A512;
COLUMN EASTING FORMAT 999999;
COLUMN NORTHING FORMAT 9999999;
COLUMN AZIMUTH FORMAT 999;
COLUMN INCLIN FORMAT 99;
COLUMN PITCH FORMAT 99;
COLUMN OCTANT FORMAT A2;
COLUMN ENDPOINT FORMAT a3;

SELECT EASTING,NORTHING,AZIMUTH,INCLIN,PITCH,OCTANT,ENDPT,SYMBOL
  FROM LOCALITIES,STRUCTURES,STRUCTYPES
    WHERE( (STRUCTURES.TYPE = 2 AND STRUCTURES.SUBTYPE > 0)
     AND (LOCALITIES.MAPNO = 3140) AND PRIORITY = 1)
     AND LOCALITIES.LOCNO  = STRUCTURES.LOCNO
     AND LOCALITIES.ORIGNO  = STRUCTURES.ORIGNO
     AND STRUCTURES.TYPE   = STRUCTYPES.TYPE
     AND STRUCTURES.SUBTYPE = STRUCTYPES.SUBTYPE
  ORDER BY EASTING,NORTHING;
SPOOL OFF;
```

Figure 4:

SQL batch file named O2A.SQL. This file selects cleavage data with a plotting priority of 1 and plot symbol strings in the correct format for conversion to an ARC/INFO GENERATE file using O2A.

```
EASTING NORTHING AZIMUTH INCLIN PITCH OC     ENDPT
------- -------- ------- ------ ----- -- ----------
SYMBOL
--------------------------------------------------------------------------

 305588 6822596    295    38            75
1001 -150,75.0 -150,0 150,0 150,75

 313322 6818501    236    34           100
1001 -150,0 150,0 1001 37.5,0 0,100 1001 0,100 -37.5,0 1001 -12.5,66.6 12.5,66.6 1001 -25,33.3 25,33.3

2 records selected.
```

Figure 5:

An example of a symbol string and the symbol generated, showing annotation features and vector features.