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Computer-constructed block diagrams of folded and thrust-faulted strata

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Abstract—Short Fortran 77 programs with a microcomputer and printer can construct model block diagrams of strata affected by two generations of folds or by multiple foreland-verging thrusts with or without contemporaneous hinterland-verging thrusts.

INTRODUCTION

The isometric block diagrams of Figs. 1 & 2 are listings of files generated by the programs REFOLD and THRUST that model folded and thrust-faulted strata. In these listings, printed vertically, letters represent different rock units. The programs run on an IBM-PC with 256K RAM. Although the algorithms do not reflect in detail the deformational processes involved, they are sufficiently alike for the models to be used to help interpret structure and teach structural principles. The versions treated here, which can easily be augmented to suit the needs of individual users, contain only 140 (REFOLD) and 350 (THRUST) lines of code.

PROGRAM REFOLD

Models constructed by REFOLD (Charlesworth & McLellan 1986), similar to those of Thiessen (1986), display two generations of sinusoidal folds of variable amplitude and wavelength. Although F_2 folds are horizontal and upright, the orientations of F_1 folds can be varied. Parameters such as amplitude and wavelength, specified in terms of character spacings, are entered at the terminal in response to prompts that appear on the monitor. Figure 1 can be considered to have been created by: (1) shearing three two-dimensional integer arrays representing the three faces; (2) converting the integers to characters; (3) for each vertical line of the block diagram placing parts of the sheared arrays into a one-dimensional array; and (4) writing each one-dimensional array into a line of the output file.

The S face of the model displays a cross-section of F_1 folds. The undeformed array for this face is such that each horizontal E–W column contains the same integer whose value increases incrementally upwards. To create upright folds, a digital cosine function representing the profile of a horizon affected by the folds is entered into a one-dimensional array and the Ith element in this array is added to each element in the Ith vertical row of the two-dimensional array. At this stage the folds are upright shear folds whose kinematic axis is vertical. To impart an E dip to the axial planes of these folds, the two-

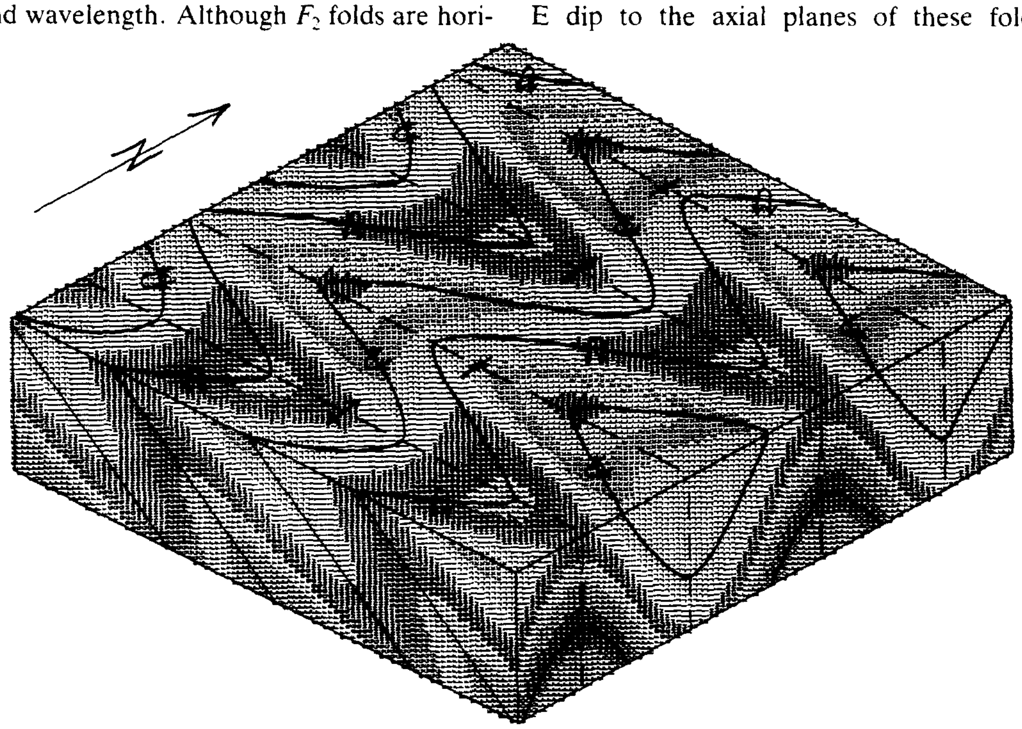

Fig. 1. Model 30° isometric block diagram, constructed using the program REFOLD, representing strata affected by F_1 (solid) and F_2 folds (broken lines).

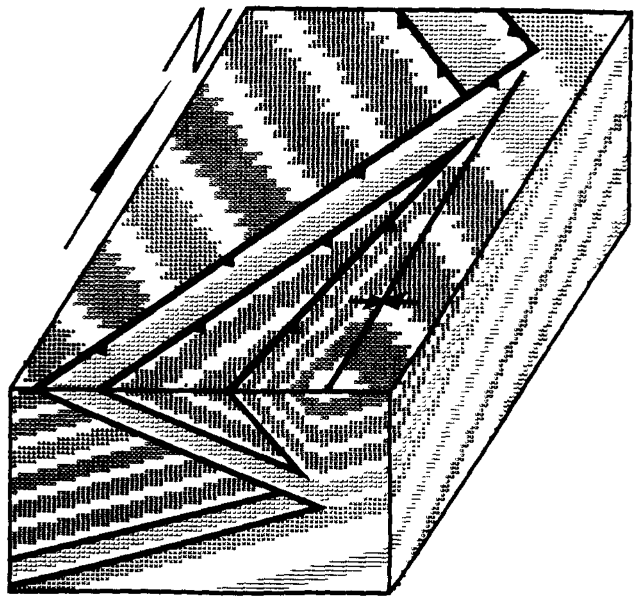

Fig. 2. Model 60° isometric block diagram of an intercutaneous wedge constructed using the program THRUST.

dimensional array is subjected to simple shear such that each horizontal column is shifted horizontally to the W by an amount proportional to the number of the column and inversely proportional to the tangent of the dip. If the axial planes of F_1 folds dip at less than 45°, a procedure beginning with vertical strata and recumbent folds is used.

The E face displaying F_2 folds is constructed in a manner similar to the S face. For the top face of the model, the Ith E–W column is the same as the Jth horizontal E–W column in the S face, J being controlled by the vertical dimension of the model, I, the tangent of the plunge of F_1 folds and by the Ith element in a one-dimensional array representing the profile of F_2 folds. Although construction of diagrams such as Fig. 1 is most readily envisaged in terms of three two-dimensional arrays, in fact only one-dimensional arrays are used, thereby reducing the size of the executable file.

PROGRAM THRUST

The program THRUST, similar to the programs of Jones (1982) and Charlesworth & Gagnon (1985), models a thrust belt containing one or more foreland-verging thrusts with or without contemporaneous hinterland-verging thrusts. Deformation occurs in stages for each of which the user specifies the horizontal displacement and the horizontal widths and dips of the flats and frontal ramps of the thrusts. Because there may be many deformational stages, values of input variables are read from a file rather than entered at the terminal. The diagram of Fig. 2 can be considered to have been created from three two-dimensional integer arrays of which those for the E and top faces have been sheared to give a three-dimensional appearance.

The array for the S face at the onset of deformation is the same as that for REFOLD. For each deformational stage, a one-dimensional array representing the trace of the E-verging thrust on the S face is constructed from input data. That part of the two-dimensional array above the thrust, i.e. the hangingwall, is displaced to the E by an amount equal to the horizontal displacement. If the thrust has a staircase geometry, the hangingwall is strained in order to conform to the shape of the undeformed footwall. Whereas hangingwall strain in thrust-belts is achieved mainly by flexural slip folding, the dip of the axial planes of fault-bend folds being controlled by various factors, strain in the model is achieved by simple shear along vertical planes. West-verging thrusts are dealt with in a similar manner.

During each deformational stage, strata disappear from view along the E and top boundaries of the S face and are replaced by new strata arriving from the W. The two-dimensional array at the end of one stage is deformed during the next stage in the same way that the undeformed array is deformed during the first stage. At the end of deformation, to impart a W dip to the S face, the two-dimensional array is subjected to vertical, counter-clockwise simple shear.

The array representing the E face is derived from the last (easternmost) vertical row of the two-dimensional array for the S face at the end of deformation and from the value of the S plunge requested by the user. The Ith E–W column in the two-dimensional array representing the top face of the model is the same as the Jth E–W horizontal column in the array representing the S face at the end of deformation, J being a function of the vertical dimension of the model, I and the S plunge.

The method used to generate the output file from the two-dimensional arrays resembles that in REFOLD. To reduce the size of the executable file, the only two-dimensional array constructed is that for the S face of the model. The models are area-balanced but only thickness measured vertically remains constant and the axial planes of fault-bend folds are vertical.

Although the program THRUST does not produce geometrically accurate models, it is short and output can go to a printer. A program producing more realistic models, written by Brian Klappstein at the University of Alberta, is 10 times longer and requires a plotting package.

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