ACTA MONTANA IRSM AS CR (1996)
Series A, No.9 (100), 187–191

PEX IMAGE OF WESTERN BOHEMIA A PRIORI SEISMIC MODEL

VÁCLAV BUCHA

Institute of Rock Structure and Mechanics, Academy of Sciences of the Czech Republic
V Holešovičkách 41, 182 09 Prague 8, Czech Republic

ABSTRACT. A possible method how to visualise Western Bohemia a priori velocity model is described. The model is composed of the realistic topography and of the artificial single complex block of velocities. Computer program ***wbzpex*** that utilizes 3D graphics library PEXlib was developed and used to render the model in the X Window System.

1. INTRODUCTION

The first part of the paper characterizes the 3–D seismic model. The model is prepared in the format suitable to the Fortran 77 modelling package MODEL built on the basis of the paper by Červený, Klimeš & Pšenčík (1988). The second part of the paper represents main features of the computer program ***wbzpex***. The source code of the program is written in C language and uses a programming library PEXlib 5.1 for 3D graphics. The presented paper takes advantage of the previous rendering experiments [Bucha 1996].

2. SEISMIC MODEL

Western Bohemia a priori model was assembled by Luděk Klimeš as a test model resembling the conditions of refraction seismic measurements performed in Western Bohemia [Bucha et al. 1992], and as the basis for the preparation of the starting a priori model for future refraction travel–time inversion [Klimeš 1995]. Figure 1 represents a truncated numerical description of the a priori model. The model consists of the Earth surface and of one velocity block.

a) Earth surface

Because of strong velocity gradients near the Earth surface, it is not possible to simplify the reference surface to, for instance, a horizontal plane, since the distances between receivers and corresponding endpoints of rays would be too long for a travel–time extrapolation [Klimeš 1995]. The horizontal model area 60×70 km (part of Germany) was covered by rectangular grid of 1 km grid interval, and 61×71 elevations of the Earth surface above the sea were digitized at grid nodes from maps. The model co–ordinate values are specified in a modified right–handed Cartesian

```
'WESTERN BOHEMIA:  EXTENDED A PRIORI MODEL WITH SURFACE'
0 1 1                                  (Cartesian co-ordinates, velocities, loss factors)
 850 910 980 1050 -12  1.1             (boundaries of the model)
1 SURFACE
1 SIMPLE BLOCK:
1 /
1 COMPLEX BLOCK:
1 /

'EARTH SURFACE' 1
  1   2  -3   0            (function describing the surface i.e. W(X1,X2)-X3=0, TENSION=0)
 61  71                    (numbers of grid points)
 850  851  852  853  854  855  856  857  858  859
  .    .    .    .    .    .    .    .    .    .    .
 900  901  902  903  904  905  906  907  908  909  910        (X1 grid co-ordinates)

 980  981  982  983  984  985  986  987  988  989
  .    .    .    .    .    .    .    .    .    .    .
1040 1041 1042 1043 1044 1045 1046 1047 1048 1049 1050  (X2 grid co-ordinates)

.695 .700 .660 .600 .570 .634 .690 .760 .769 .718
  .    .    .    .    .    .    .    .    .    .    .
.390 .423 .409 .390 .403 .470 .503 .457 .505 .500 .500
  .    .    .    .    .    .    .    .    .    .    .
  .    .    .    .    .    .    .    .    .    .    .
.536 .546 .558 .543 .597 .581 .607 .609 .612 .609
  .    .    .    .    .    .    .    .    .    .    .
.511 .517 .537 .528 .525 .500 .488 .484 .443 .477 .508        (X3, elevations)
'END OF SURFACES' /

'COMPLEX BLOCK' 1
'VP ' 1
  1   2   3   0            (function describing the material i.e. VP=W(X1,X2,X3), TENSION=0)
  7   8   5                (numbers of grid points)
 910  900  890  880  870  860  850                 (X1)
 980  990 1000 1010 1020 1030 1040 1050            (X2)
  1   0  -1  -4  -10                               (X3 grid co-ordinates)

3.60 3.30 3.00 4.20 3.90 3.60 3.30
 .    .    .    .    .    .    .
3.12 3.96 4.80 5.46 1.80 4.50 7.20        (1st)

5.20 5.15 5.10 5.30 5.25 5.20 5.14
 .    .    .    .    .    .    .
5.12 5.26 5.40 5.51 4.90 5.35 5.80        (2nd)

5.60 5.60 5.60 5.60 5.60 5.60 5.60
 .    .    .    .    .    .    .
5.60 5.60 5.60 5.60 5.60 5.60 5.60        (3rd)

5.90 5.90 5.90 5.90 5.90 5.90 5.90
 .    .    .    .    .    .    .
5.90 5.90 5.90 5.90 5.90 5.90 5.90        (4th)

6.50 6.50 6.50 6.50 6.50 6.50 6.50
 .    .    .    .    .    .    .
6.50 6.50 6.50 6.50 6.50 6.50 6.50        (5th horizontal velocity section)
'END OF COMPLEX BLOCKS, END OF THE INPUT DATA FOR THE MODEL' /
```

FIG. 1. Truncated numerical description of the a priori Western Bohemia model. The dots represent subsequent values not reprinted here. The text printed in *italics* contains remarks in order to make the data more clear.

co-ordinate system (Křovák) in kilometres. The vertical co-ordinate corresponds to the elevation above the sea.

b) velocity block

No clear reflections in the refraction seismograms have been seen thence the a priori model contains no structural interfaces. The model is composed of a single simple block that coincides with a single complex block. The velocity distribution is artificial with some respect to the refraction measurements.

P-wave velocities are specified in the grid of $7 \times 8 \times 5$ points. Each subtable of velocity values (see Fig. 1) corresponds to a horizontal velocity section. The velocity sections are ordered with increasing depth. Below the elevation of -1 km, there is a 1-D velocity distribution with a constant vertical gradient [Klimeš 1995].

3. PEX IMAGE OF THE SEISMIC MODEL

Figure 2 showing the image of the velocity block with the Earth surface was scanned with 8-bit greyscale from colour originals. The grey shades unfortunately do not express colours and colour shades exactly and the resolution is poor. The elevations were 15 times enlarged and the vertical co-ordinates of the velocity block were enlarged twice with respect to the horizontal scale.

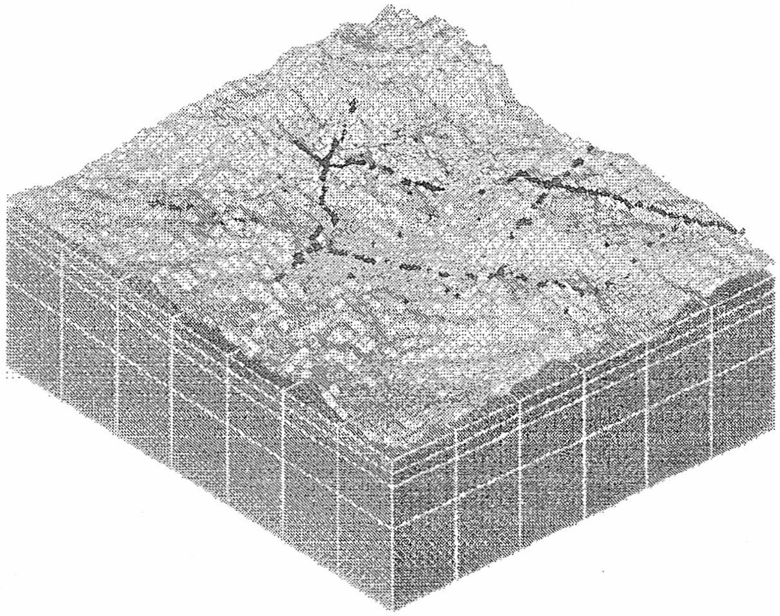

FIG. 2. PEX image of Western Bohemia a priori velocity model.

The block of velocities is defined in a rectangular grid where differences between velocities are expressed by colours and shades (velocity increases by the colour scale blue-violet-red). PEXlib function *"Set of fill area sets with data"* was used to render block of velocities. The function enables us to set vertex normals, vertex colours, facet normal, facet colour and edge visibility flag for each facet [Gaskins 1992]. The function *"Quadrilateral mesh"* was used to render terrain elevation. Actual seismic stations and refraction measurement points are imagined on the surface.

Program ***wbzpex*** uses Gouraud shading method that calculates reflectance at each vertex of a facet, interpolating the resultant reflected colours across the facet. The program uses ambient and directional lights and reflection is set to specular. The source code contains functions that were taken from O'Reilly&Associates example codes and modified.

Mouse movement and mouse buttons depression interactively controls the program. Mouse activity generates Xlib events that are received and handled in the program. Clicking the pickable object enables us to switch to other action. Following objects are pickable: seismic model, descriptions of axes X, Y, Z.

Interactive actions:

1. *Panning* (rotation) is started when you click the seismic model. Panning around the model is accomplished by changing the view plane normal in response to mouse movement that is controlled by holding the first mouse button and moving the mouse in the direction that you want to go.
2. *Zoom* can be performed in the same session as the rotation. Zoom in (you are going closer to the model) is performed by clicking the second mouse button and zoom out can be similarly implemented by simultaneous depression of the second mouse button and holding the left shift button on the keyboard.
3. *Clipping* is started by clicking one of three axes description (X, Y, Z). The clipping plane is perpendicular to each axis and the position of the plane is controlled by movement of the mouse when the second button is pressed.

The program ***wbzpex*** runs only in the X Window System environment so you can use dump (xwd) and print (xpr) commands with the appropriate options for the output.

4. CONCLUSION

The described version of program ***wbzpex*** is assigned to render the Western Bohemia a priori model primarily. The program was tested only with this model specification so the program cannot be used for other models suitable to Fortran 77 modelling package format at present. There have to be made many improvements to generalize the use of the program and to make it user–friendly.

Acknowledgments: This research was supported by the Grant Agency of the Academy of Sciences of the Czech Republic under the project A346110 "Seismic tomography and refraction data processing".

REFERENCES

Bucha V., Klimeš L., Dvořák V., Sýkorová Z. (1992), *Refraction 3-D seismic measurements in Western Bohemia*, Proc. of XXIII General Assembly of the European Seismological Commission, Praha, pp. 155–158.

Bucha V. (1996), *Rendering of 3-D seismic model*, Acta Montana, in this volume.

Červený V., Klimeš L., Pšenčík I. (1988), *Complete seismic-ray tracing in three-dimensional structures*, In: Doornbos, D.J. (ed.), Seismological Algorithms, Academic Press, New York, pp. 89–168.

Gaskins T. (1992), *PEXlib Programming Manual*, O'Reilly&Associates, Inc., Sebastopol.

Klimeš L. (1995), *Examples of seismic models*, In: Seismic waves in complex 3-D structures, Report 3., Department of Geophysics, Faculty of Mathematics and Physics, Charles University, Prague, pp. 5–35.