Marmousi Model

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Data Type: *Synthetic 2D acoustic model*
Source: *Institut Français du Pétrole*
Location: *http://www.ifp.fr/IFP/en/aa.htm*
Format: *Native, originally Sierra Geophysical Format*
Date of origin: *1988*

INTRODUCTION

The Marmousi model was created in 1988 by the Institut Français du Pétrole (IFP) in 1988. The geometry of this model is based on a profile through the North Quenguela trough in the Cuanza basin. The geometry and velocity model were created to produce complex seismic data which require advanced processing techniques to obtain a correct earth image. The Marmousi dataset was used for the workshop on practical aspects of seismic data inversion at the 52nd EAEG meeting in 1990.

Since its inception in 1990 Marmousi has come be a sort of industry standard and almost classic dataset. The Madagascar repository contains the Marmousi files shown in Table 1.

```
1 -rwxr-xr-x    1 root     root       610095 2005-04-20 07:34 marmsmooth.HH
2 -rwxr-xr-x    1 root     root     66909210 2005-04-20 07:34 marmrefl.hh
3 -rwxr-xr-x    1 root     root      6913301 2005-04-20 07:34 marmvel.hh
4 -rwxr-xr-x    1 root     root       754664 2005-04-20 07:34 marmousi.HH
5 -rw-r--r--    1 root     root       708382 2006-05-19 06:19 marmvz.HH
6 -rw-r--r--    1 root     root       708382 2006-05-19 06:19 marmvx.HH
7 -rw-r--r--    1 root     root       708200 2006-05-19 06:19 marmeta.HH
```

Table 1: A list of all files contained in the Marmousi repository

MODEL

The Marmousi model contains 158 horizontally layered horizons. A series of normal faults and resulting tilted blocks complicates the model towards its center. The model sits under approximately 32 m of water and is 9.2 km in length and 3 km in depth.

The velocity model found in the Madagascar repository, *marmvel.hh* can easily be displayed. This grid contains 751 data points in the Z direction and 2301 data points in the x direction. Table 2 displays the proper header configuration.

n1=751	d1=.004	o1=0	label= Depth	unit1=km
n2=2301	d2=.004	o2=0	label2=Position	unit2=km

Table 2: Header information for Marmousi velocity models

The script found at *marmousi/model/SConstruct* was written to obtain the Marmousi model datasets, append the headers as necessary and display the data. This file is presented in Table 3 while the velocity model image is displayed in Figure 1.

```
from rsf.proj import *
# Fetch Files from repository
raw=['marmvel.hh','marmsmooth.HH']
for file in raw:
    Fetch(file,"marm")
    if file is 'marmvel.hh':
        d=.004
        fileOut='marmvel'
        t='Velocity\ Model'
    if file is 'marmsmooth.HH':
        d=.024
        fileOut='marmsmooth'
        t='Smoothed\ Velocity\ Model'
# Convert Files to RSF and update headers
    Flow(fileOut,file,'''dd form=native |
        scale rscale=.001 | put
        label1=Depth label2=Position unit1=km unit2=km
        d1=%f d2=%f''' % (d,d))
# Plotting Section
    Result(fileOut,'''window $SOURCE  |
        grey color=I gainpanel=a allpos=y scalebar=y
        title=%s barlabel=Velocity barunit=km/s screenratio=.326
        screenht=3 wheretitle=t labelsz=4 titlesz=6 ''' % t)
End()
```

Table 3: *SConstruct* script generating the Marmousi velocity model images

Typing Command 1 within the *Marmousi/model* directory runs the script.

```
bash-3.1$ scons view
```
(1)

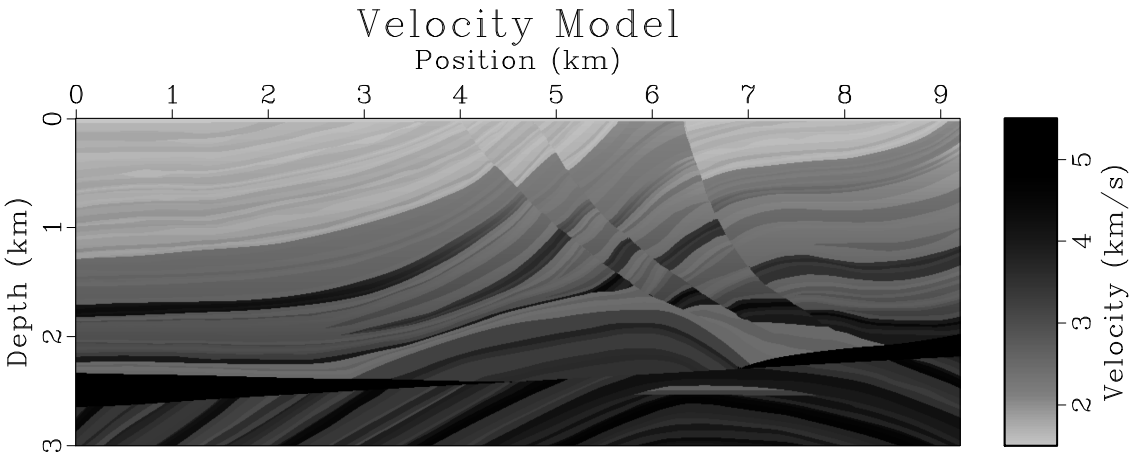


Figure 1: Velocity model

SHOT RECORDS

The file *marmrefl.hh* contains the shot data collected on the Marmousi model. The survey was an off end survey with receivers to the left of the source being pulled towards the right. Receiver as well as shot spacing is every 25 meters. Near offset is 425 meters from the source. 726 time gates were recorded with 4ms spacing for roughly 3 seconds of data

n1=726	d1= 0.004	o1=0.000	label1=Depth	unit1=s
n2=96	d2=-0.025	o2=2.575	label2=Offset	unit2=km
n3=240	d3= 0.025	o3=3.000	label3=Shot-coord	unit3=km

Table 4: Shot header information for Marmousi.

collection. Madagascar correctly converts this file according to its header; however, the correct shot header values are reproduced in Table 4.

The file *marmousi/shots/SConstruct* gathers shot data, appends the header as necessary and produces several plots of the data. This file is reproduced here in Figure 5

```
1
2  from rsf.proj import *
3  # Fetch Files from repository
4  Fetch("marmrefl.hh","marm")
5
6  # Convert Files to RSF and update header
7  Flow('marmrefl','marmrefl.hh', '''dd form=native | put
8      label1=Depth\ Z label2=Offset unit2=km unit1=sec
9      label3=Position unit3=km d2=-.025 d3=.025 o2=2.575 o3=3''')
10
11 # Plotting Section
12 #Result('marmrefl','window j3=10 | grey')
13
14 Result('nearOffset','marmrefl','''window $SOURCE min2=.200 max2=.200 size2=1 |
15     grey color=I gainpanel=a title=Near\ Offset\ Data label1=Time label2=Position
16     screenratio=1.3 labelsz=4 titlesz=6 wheretitle=t''')
17
18 Result('shot20','marmrefl','''window $SOURCE min3=3.500 max3=3.500 size3=1 |
19     grey color=I gainpanel=a title=Shot\ \#\ 20 wantframenum=y label2=Offset
20     label1=Time screenratio=1.3 labelsz=4 titlesz=6 wheretitle=t''')
21 End()
```

Table 5: *SConstruct* script generating the Marmousi shot images

To run the script type Command 2 within the *marmousi/shots* directory.

```
bash-3.1$ scons view                                    (2)
```

FINITE DIFFERENCE MODELING

Madagascar can perform finite difference modeling on the Amoco Velocity model. This is done using the function fdmod. The raw velocity model needs to be formatted in a similar fashion to the Model Section of this paper.

For the purposes of this example a shot will be fired at 5 km along the horizontal coordinate and at a depth of 10 meters. Receivers are spread at a depth of 25 meters every 12.5 meters along the entire scope of the model. This long receiver cable is impractical but useful for these purposes. Data is recorded on every receiver at time increments of 1 ms 5000 times resulting in 5 seconds of data. In practice it would be necessary to perform longer running models, but this number of time gates is sufficient for this introduction.

An *SConstruct* file located within *marmousi/fdmod/* properly formats the model and inputs necessary parameters to perform a shot on the Marmousi model. This file is reproduced below in Table 6.

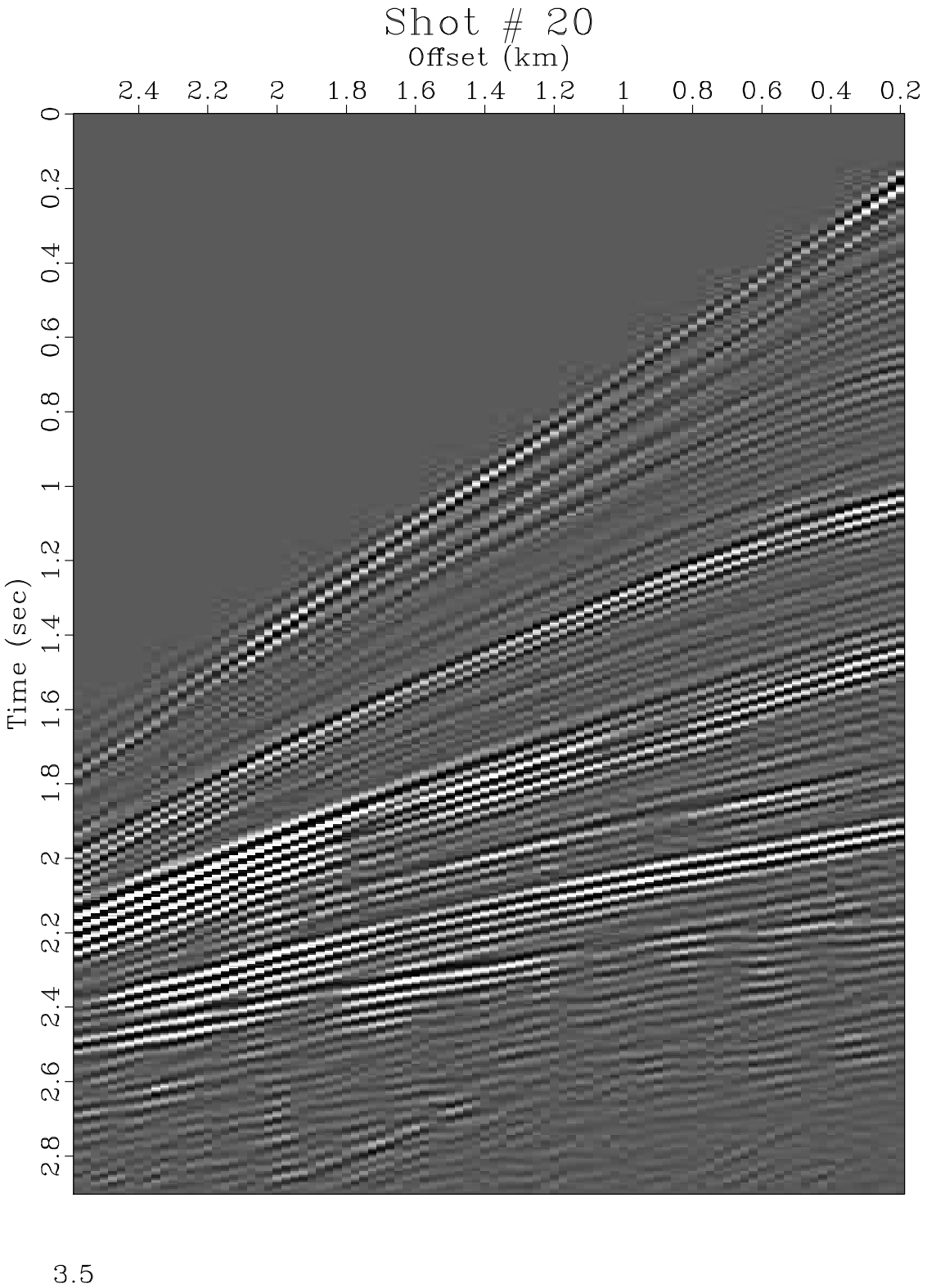


Figure 2: Shot number 20 of Marmousi synthetic survey dataset. Shot position in km is shown in the lower left hand corner.

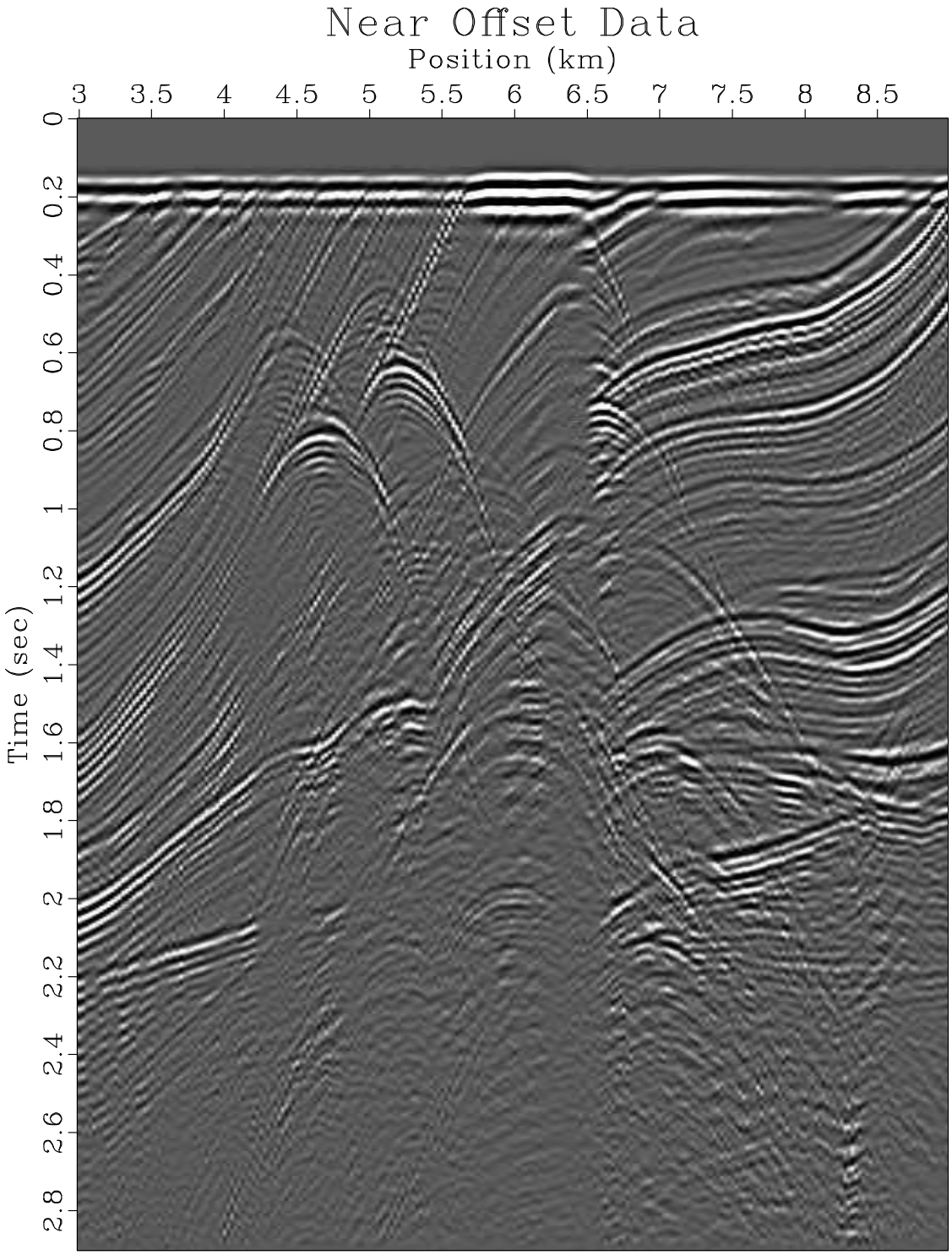


Figure 3: Near offset data for Marmousi model

```
from rsf.proj import *
import fdmod
# Fetch Files from repository
raw=['marmvel.hh','marmsmooth.HH']
for file in raw:
    Fetch(file,"marm")
    if file is 'marmvel.hh':
        d=.004
        fileOut='marmvel'
        t='Velocity\ Model'
    if file is 'marmsmooth.HH':
        d=.024
        fileOut='marmsmooth'
        t='Smoothed\ Velocity\ Model'
# Convert Files to RSF and update headers
    Flow(fileOut,file,'''dd form=native |
        scale rscale=.001 | put
        label1=Depth label2=Position unit1=km unit2=km
        d1=%f d2=%f''' % (d,d))
# Plotting Section
    Result(fileOut,'''window $SOURCE  |
        grey color=I gainpanel=a allpos=y scalebar=y
        title=%s barlabel=\(km\/s\) screenratio=.326
        screenht=3 wheretitle=t labelsz=4 titlesz=6 ''' % t)

# ------------------------------------------------------------
par = {
    'nt':10000, 'dt':0.00025,'ot':0,'lt':'t','ut':'s',
    'nx':2301, 'ox':0, 'dx':.004, 'lx':'x','ux':'km',
    'nz':751,  'oz':0, 'dz':.004, 'lz':'z','uz':'km',
    'kt':400    # wavelet delay
    }
# add F-D modeling parameters
fdmod.param(par)
# ------------------------------------------------------------
# wavelet
Flow('wav',None,
         '''spike nsp=1 mag=1 n1=%(nt)d d1=%(dt)g o1=%(ot)g k1=%(kt)d |
         ricker1 frequency=15 | scale axis=123 |
         put label1=t label2=x label3=y | transp''' % par)
Result('wav',
       'transp | window n1=1000 | graph title="" label1="t" label2= unit2=')
# ------------------------------------------------------------
# experiment setup
Flow('r_',None,'math n1=%(nx)d d1=%(dx)g o1=%(ox)g output=0' % par)
Flow('s_',None,'math n1=1      d1=0      o1=0      output=0' % par)
# receiver positions
Flow('zr','r_','math output=.025')
Flow('xr','r_','math output="x1"')
Flow('rr',['xr','zr'],'''cat axis=2 space=n
     ${SOURCES[0]} ${SOURCES[1]} | transp
     ''', stdin=0)
Plot('rr',fdmod.rrplot('',par))
# source positions
Flow('zs','s_','math output=.01')
Flow('xs','s_','math output=5.0')
Flow('rs','s_','math output=1')
Flow('ss',['xs','zs','rs'],'''
     cat axis=2 space=n
     ${SOURCES[0]} ${SOURCES[1]} ${SOURCES[2]} | transp
     ''', stdin=0)
Plot('ss',fdmod.ssplot('',par))
# ------------------------------------------------------------
# density
Flow('vel','marmvel',
     '''
      put o1=%(oz)g d1=%(dz)g  o2=%(oz)g d2=%(dz)g
     ''' % par)
Plot('vel',fdmod.cgrey('''allpos=y bias=1.5 pclip=97 title=Survey\ Design
                  color=G titlesz=6 labelsz=4 wheretitle=t barrevers=y''',par))
Result('vel',['vel','rr','ss'],'Overlay')
# ------------------------------------------------------------
# density
Flow('den','vel','math output=1')
# ------------------------------------------------------------
# finite-differences modeling
fdmod.awefd('dat','wfl','wav','vel','den','ss','rr','free=y dens=y',par)

Plot('wfl',fdmod.wgrey('pclip=99',par),view=1)
Result('dat','window j2=5 | transp |' + fdmod.dgrey('''pclip=99 title=Data\ Record label2=Offset
            wheretitle=t titlesz=6 labelsz=4''',par))

times=['.5','1.0','1.5','2.0']
cntr=0
for item in ['20','40','60','80']:
    Result('time'+item,'wfl',
           '''
           window f3=%s n3=1 min1=0 min2=0 | grey gainpanel=a
           pclip=99 wantframenum=y title=Wavefield\ at\ %s\ s labelsz=4
           label1=z unit1=km label2=x unit2=km
           titlesz=6 screenratio=.18 screenht=2 wheretitle=t
           ''' % (item,times[cntr]))
    cntr=cntr+1

End()
```

Table 6: *Scons* script that performs a finite difference synthetic shot on the Marmousi model.

Typing Command 3 within the *marmousi/fdmod/* directory runs the FD modeling script.

```
bash-3.1$ scons view
```
(3)

This script first constructs the survey acquisition geometry as was previously mentioned. An image of the survey is created and presented in Figure 4.

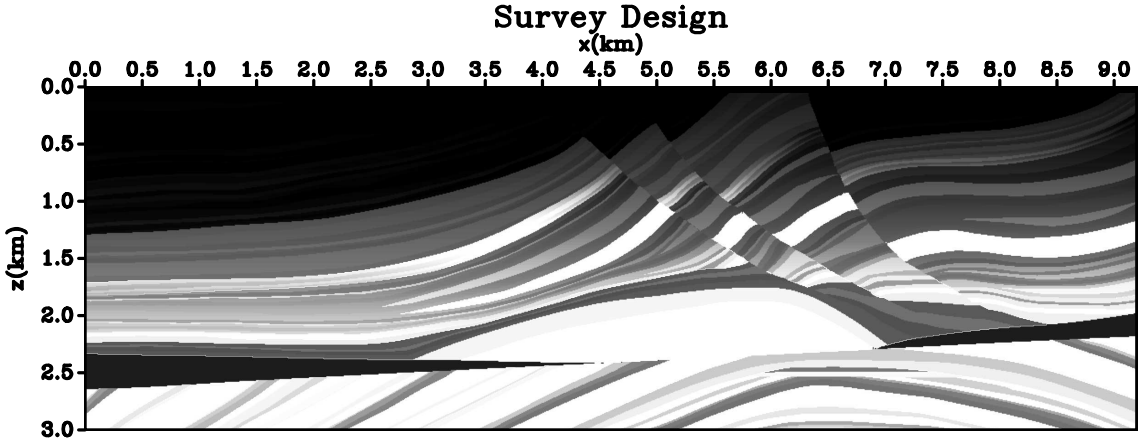
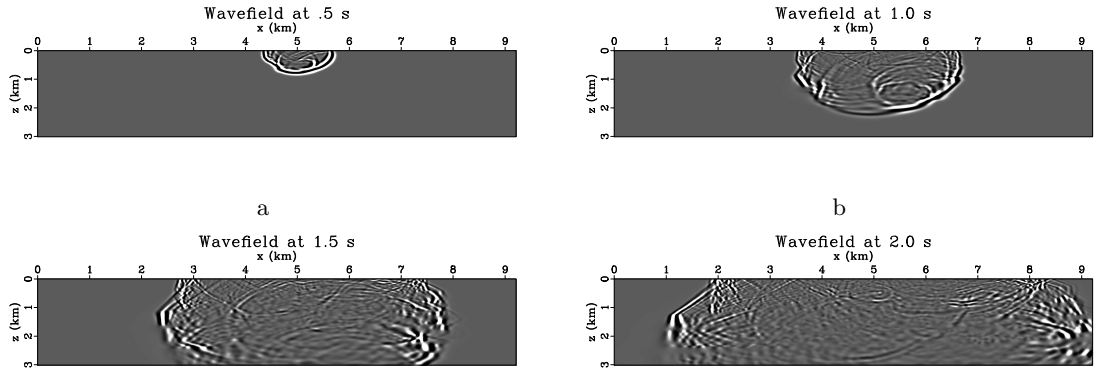


Figure 4: FD model geometry as performed on the Marmousi velocity model. The *X* represents the shot while the * symbols represent receivers.

Firing the shot results the propagation of a wavefield which can be seen in the movie *wfl.vpl* that is generated. Typing Command 4 within the *marmousi/fdmod* directory displays the wavefield movie.

```
bash-3.1$ scons wfl.vpl
```
(4)

Four frames from this movie are presented in Figure 5 illustrating the propagation of the wavefield in the model.



a b c d

Figure 5: Images of the propagating wavefield in the Marmousi model generated by a finite difference model.

The resulting data is then presented in the file *dat.vpl*. This plot is reproduced here in Figure 6.

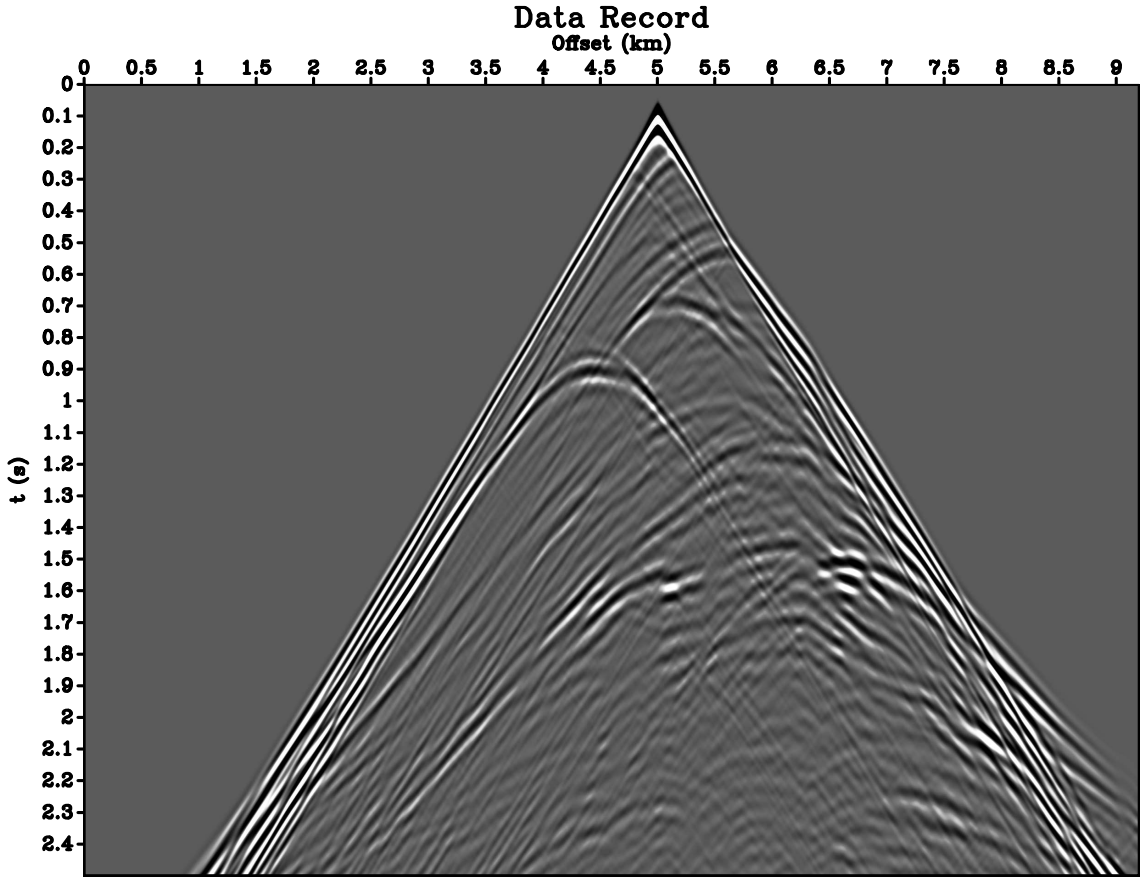


Figure 6: Data gathered by the receivers in the FD model survey.