APPENDIX A

Synthetic Model

Modeling really aims to create geophysical models and explain them better as a guideline processing to any exploratory action. The modeling consist seven homogeneous layer by using a Finite-Difference Modeling (2nd order) for acoustic wave equation (sufdmod2) of Seismic Unix software (SU). This software is developed by the Center for Wave Phenomena (CWP) at the Colorado School of Mines. There are two steps of modeling, (a) creation geological model and (b) applying the wave equation to generate wave equation into the designed model.

The code of geological model shows that:

```
0 0
10000 0
1 -99999
0 250
10000 250
1 -99999
0 500
10000 500
1 -99999
0 1000
10000 1000
1 -99999
0 2000
10000 2000
1 -99999
0 2500
10000 2500
1 -99999
0 4000
```

```
10000 4000
1 -99999
0 5000
10000 5000
1 -99999
0 15000
10000 15000
1 -99999
```

The code of applying the wave equation shows that:

```
#! /bin/sh
# variables
Nx=2000
Nz=2000
Dx=5
Dz=5
Zs=10
fmax=25

# building the model with "unif2"
unif2 < Model ninf=8 nx=$Nx nz=$Nz dx=$Dx dz=$Dz
v00=1500,1800,2200,3000,3500,4000,4500,5500 > velocity.1
unif2 < Model ninf=8 nx=$Nx nz=$Nz dx=$Dx dz=$Dz v00=1.5,2,2.2,2.2,2.5,2.5,2.6,3.5 > density.1

# view the model
ximage < velocity.1 title="velocity profile" legend=1 xbox=10 ybox=10 n1=$Nz n2=$Nx d1=$Dz
d2=$Dx &
ximage < density.1 title="density profile" legend=1 xbox=10 ybox=10 n1=$Nz n2=$Nx d1=$Dz
d2=$Dx &

# applying the wave equation
i=100
while [ "$i" -le "100" ]
do
  Xs=`bc -l <<-END
  $i * 50
  END`
  fldr=`expr $i - 99`
```

```
echo "shotrecord=$fldr    s_location=$Xs"
        sufdmod2 < velocity.1 xs=$Xs zs=$Zs nx=$Nx nz=$Nz dx=$Dx dz=$Dz tmax=12
fmax=$fmax nt=17301 hsz=10 hsfile=hsfile.su abs=0,1,1,1 verbose=2 mt=200 dfile=density.1 >
cube.out

suwind < hsfile.su key=tracr reject=1 | sushw key=tracr,tracl a=1,1 b=1,1 | suwind j=5 | suwind
key=offset min=-1500 max=1500 | suwind key=offset reject=0 |sushw key=fldr,d2 a=$fldr,25 | sushw
key=tracf a=1 b=1 >> temp.su
i=`expr $i + 1`
done

# changing header and resampling
sushw < temp.su key=tracl,tracr a=1,1 b=1,1 | suresamp nt=1201 dt=.004 > FDmodel.su

# view shot output
sugain agc=1 wagc=1 < FDmodel.su | suxwigb perc=99 &

exit 0
```

APPENDIX B

Residual static

In an early stage the general static corrections were discussed. Especially, the correction for the topography and the influence of the weathered layer were discussed. The aim of the static corrections is to shift individual traces in such a way that the reflections in a common midpoint gather lie as accurate as possible along a hyperbola. Topographic corrections and refraction statics solve this problem only for a certain part. Most of the times small shifts between traces remain. To correct for these small shifts the residual static correction is applied.

Principle of Residual statics

The process of residual statics consists of shifting the separate traces in such a way that the optimal reflections are obtained. To make sure that the traces of a single CMP are not shifted randomly, the shift is devided in a value for the source ("source static") and a value for the receiver ("receiver static"). For each source and receiver a value is determined. All traces with a certain source are corrected with the value for that source. Similarly all traces with a certain receiver are corrected with the value for that receiver. The resulting shift (static correction) of a trace consists of the correction value of the source and receiver of the corresponding trace. The residual static correction flow shows in Figure B-1.

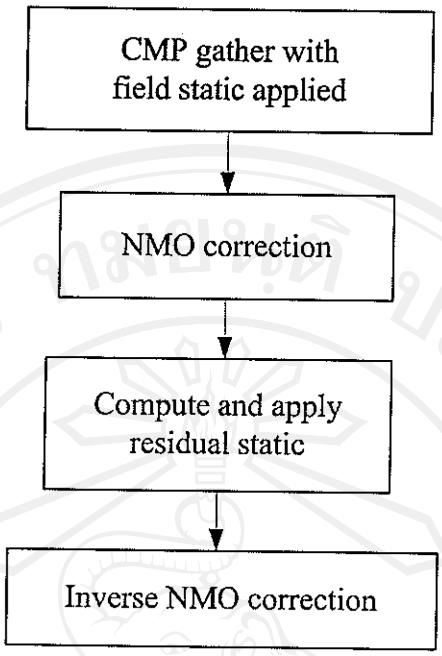

Figure B-1 Scheme of residual static correction.

APPENDIX C

The *tau-p* formula for the multi-layer

Consider a subsurface model consisting of a sequence of flat horizontal homogeneous layers. Suppose a source and receiver on the surface separated by the offset x, and consider a primary ray going from source to receiver which reflects off the base of layer n, Figure C-1. Let v_j be the velocity of layer j (i.e., the interval velocity), h_j be the thickness of layer j and t be two-way travel time of the primary ray.

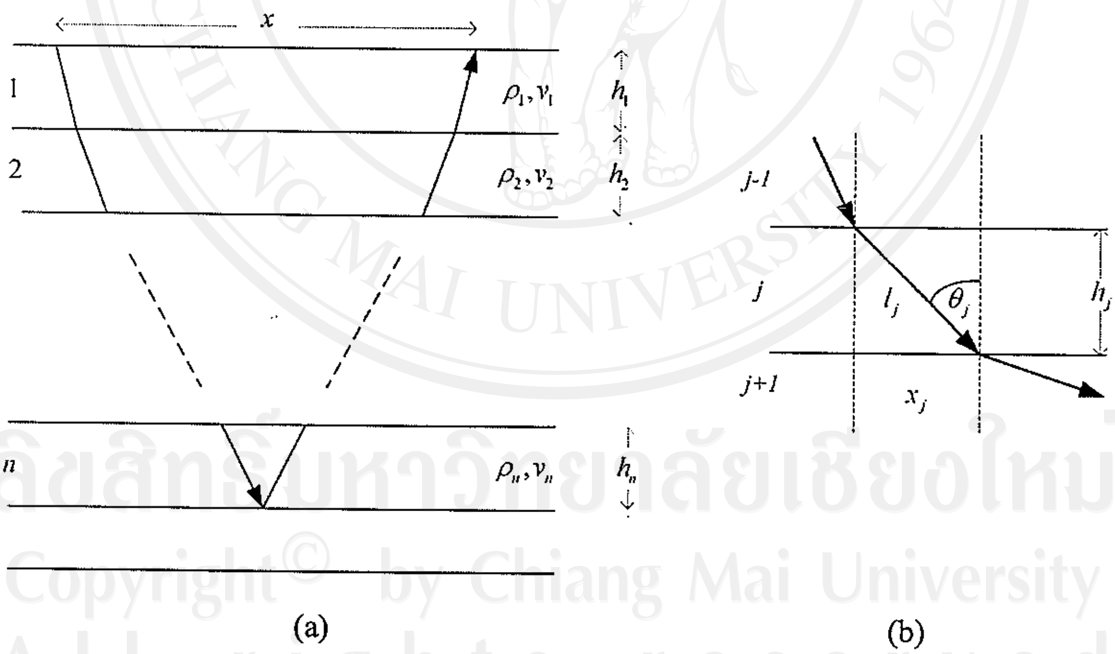

Figure C-1 (a) The subsurface model n layer. (b) The ray path in jth layer (Krebes, 1989).

For n layers in Figure C-1, the reflected traveltime (t_R) given by

$$t_R = 2\sum_{j=1}^{n}\frac{l_j}{v_j} = 2\sum_{j=1}^{n}\frac{h_j}{v_j\cos\theta_j}\ , \tag{1}$$

where l_j is ray path of the ray segment in layer j and p is the ray parameter or horizontal slowness, $p = \dfrac{\sin\theta}{v}$, thus can be written as

$$\sin\theta = pv \quad \text{and} \quad \cos\theta = \sqrt{1-p^2v^2}\ .$$

Replace $\cos\theta$ to equation (1), which results in

$$t_R = 2\sum_{j=1}^{n}\frac{h_j}{v_j\sqrt{1-p^2v_j^2}}\ . \tag{2}$$

Similarly, for the offset x, can be written as

$$x = 2\sum_{j=1}^{n}x_j = 2\sum_{j=1}^{n}h_j\tan\theta_j = 2\sum_{j=1}^{n}h_j\frac{\sin\theta_j}{\cos\theta_j} \tag{3}$$

$$= 2\sum_{j=1}^{n}h_j\frac{\sin\theta_j}{\sqrt{1-\sin^2\theta_j}}\ ,$$

$$= 2\sum_{j=1}^{n}\frac{h_jv_jp}{\sqrt{1-p^2v_j^2}}\ . \tag{4}$$

Linear *tau-p* transformation involves summation along line

$$t = \tau + px\ . \tag{5}$$

To prove the equation (5), simply substitute equation (2) for total traveltime t and equation (4) for x, thus the intercept time τ is

$$\tau = \sum_{j=1}^{n}\tau_j = 2\sum_{j=1}^{n}\frac{h_j}{v_j}\sqrt{1-p^2v_j^2}\ , \tag{6}$$

$$\tau_j = \frac{2h_j}{v_j}\sqrt{1-p^2v_j^2} \quad ,$$

$$v_j^2\tau_j^2 = 2h_j^2(1-p^2v_j^2) \quad ,$$

$$v_j^2p^2 + \left(\frac{v_j}{2h_j}\right)^2 \tau_j^2 = 1 \quad . \tag{7}$$

Thus the reflected wave event on shot record (*t*-*x* domain) maps onto a ellipse on the τ - p domain with the major and minor axis length is $1/v_j$ and $2h_j/v_j$.

Consider head wave refractions in multi-layer medium, from basic reflection seismology, we know that head wave refracted from the *n*th reflector interface has a traveltime t_H given by (Telford *et al.*, 1990)

$$t_H = \frac{x}{v_{n+1}} + \sum_{j=1}^{n}\frac{2h_j\cos\theta_j}{v_j} \quad , \tag{8}$$

when in this case is the critical angle.

From Snell's law

$$\sin\theta_j = \frac{v_j}{v_{j+1}} \quad . \tag{9}$$

Rewrite equation (8),

$$t_H = \frac{x}{v_{n+1}} + \sum_{j=1}^{n}\frac{2h_j}{v_j}\sqrt{1-\frac{v_j^2}{v_{j+1}^2}} \quad . \tag{10}$$

Thus can be written as

$$p = \frac{dt}{dx} = \frac{1}{v_{n+1}} \quad , \tag{11}$$

and

$$\tau = \sum_{j=1}^{n}\frac{2h_j}{v_j}\sqrt{1-\frac{v_j^2}{v_{j+1}^2}} \quad . \tag{12}$$

Thus the head wave event on the shot record (*t-x* domain) maps onto a point in the τ - p domain. The linear *tau-p* transformation for multi-layer is shown in Figure C-2.

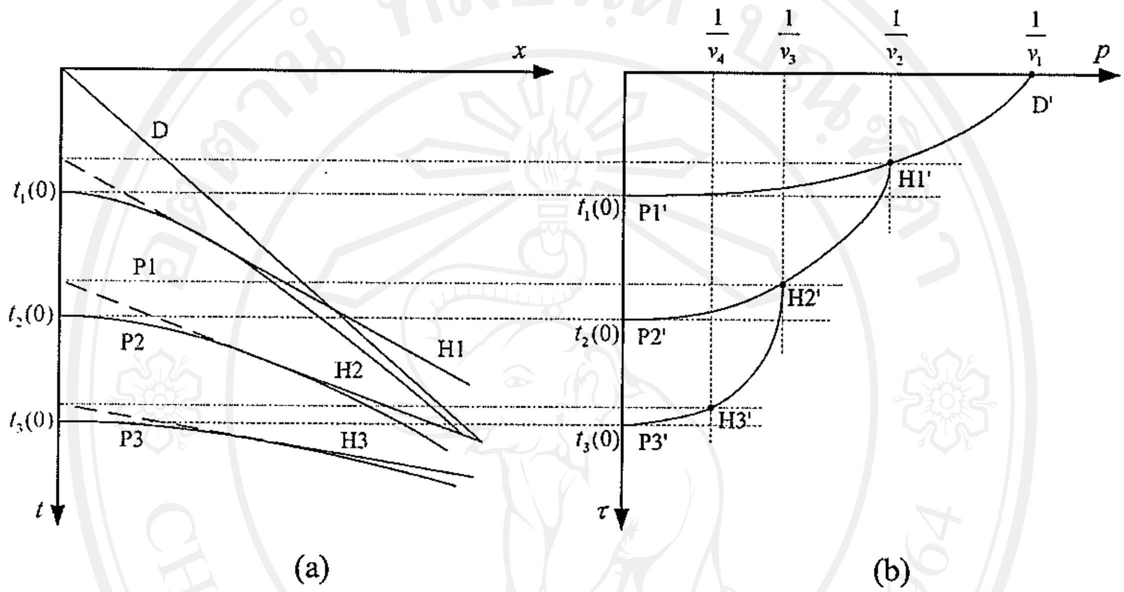

Figure C-2 (a) The shot record for three layer model which $v_1 < v_2 < v_3 < v_4$. (b) The linear *tau-p* domain that showing the reflectors (P1, P2 and P3), the head wave (H1, H2, H3) and direct wave (D) are transformed in to ellipse (P1′, P2′ and P3′) and point (H1′, H2′, H3′ and D′), respectively (modified from Krebes, 1989).

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