A SEISMIC MODEL OF THE UPPER MISSISSIPPI EMBAYMENT FROM P AND S TIMES OF LOCAL EARTHQUAKES

by

Braik M. Hashim, B.Sc.

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CHAPTER I

INTRODUCTION

Since the occurrence of the great New Madrid earthquake series of 1811-1812, the Mississippi Embayment region has been an area of interest for geophysicists and geologists. As early as 1925 a seismic network was planned by Saint Louis University to study the seismicity of this region. One of the aims of these studies has been to obtain the velocity distribution in the hope of determining the crustal structure.

Several studies of the deep velocity structure of the crust have been made in the Central United States, within a few hundred kilometers of the upper Mississippi Embayment.

Nuttli (1956), from an investigation of the shallow focus earthquake of January 29, 1956, obtained velocities of 6.1 km/sec, 6.38km/sec and 8.19 km/sec for the compressional waves and 3.48 km/sec, 3.64 km/sec and 4.67 km/sec for shear waves. In addition Nuttli pointed out that a crustal thickness between 32 and 43 km could be obtained by varying the focal depth of the earthquake over a reasonable range.

Recently, Nuttli et. al. (1969) carried out more extensive studies which included other earthquakes and controlled explosions. They constructed a travel-time table for the earthquakes which have occurred in the Central United States. The following model for crustal and upper mantle structure was obtained.

After Nuttli et. al., 1969

α = 6.15 km/sec β = 3.5 km/sec	20 km	Conrad Discontinuity
α = 6.7 km/sec β = 3.67 km/sec	20 km	Moho. Discontinuity
α = 8.18 km/sec β = 4.68 km/sec	57 km	
α = 8.37 km/sec β = 4.62 km/sec		

Warren et. al. (1966) determined a seismic model from a seismic refraction survey made in Southern Mississippi. Their velocities and layer thicknesses inferred from the travel-times of compressional waves were as follows: a 5.0 km/sec layer between 3.1 and 3.7 km thick lies just under the boundary between the Upper and Lower Cretaceous sedimentary rocks. The velocity in the upper crystalline crust is 5.9 km/sec and the thickness is 6 to 10 km. The velocity in the lower crust was found to be 6.9 km/sec, with a thickness of 13 to 19 km. The velocity found for the upper mantle

is 8.4 km/sec, and the total crustal thickness is 29 to 41 km.

A crustal profile using five fixed shot points in the Mississippi River near Cape Girardeau, Missouri was shot in the summer of 1962. From the analysis of this profile, McCamy and Meyer (1966) inferred a flat Moho discontinuity at 45 km depth, with an 8.1 km/sec mantle, overlain by a 7.4 km/sec layer 15 km thick. The upper crust (0-29 km) is characterized by gentle dips to the southwest and rather high velocities, 6.2 and 6.4 km/sec. They pointed out that it is not wise to compare the results they got with that obtained for the Central United States, since the Mississippi Embayment may well have crustal structure at depth that is entirely different from areas a few hundred kilometers away.

Stewart (1968) analyzed two reversed refraction profiles, one in northern Missouri and the other in southern Missouri. He found that the seismic data obtained from northern Missouri were of higher quality than those obtained from southern Missouri. For northern Missouri, he found that the crust is characterized by three major layers. A velocity of 6.1 km/sec extends from near the surface to a depth of 8 km. A velocity of 6.2 km/sec extends from that depth to 20 km. This is underlain by a 6.6 km/sec layer which extends to a

depth of 40 km. For the upper mantle, he found a velocity of 8.0 km/sec.

Stewart (1968) reported that the seismic data from southern Missouri were not as good as those of northern Missouri due to the increased noise levels caused by thunderstorms during the time of the field work. He found the data to be very difficult to interpret and suggested that the difficulty in part was caused by lateral inhomogeneities within the crust. He pointed out that the velocity structure of the upper half of the crust may be represented by two layers. The upper layer for southern Missouri is the same as that of northern Missouri. The velocity for the lower layer may be slightly higher in southern Missouri, about 6.3 to 6.4 km/sec. The lower half of the crust is characterized by a velocity of 7.0 km/sec or perhaps slightly higher, and the upper mantle by a velocity of 8.15 km/sec.

Stauder and Bollinger (1963) studied the travel-times from five earthquakes which occurred in the southeastern Missouri seismic region during the first seven months of 1962. They reported a velocity of 6.41 km/sec for P_g, 8.24 km/sec for P_n, 3.65 km/sec for S_g, and 4.72 km/sec for S_n. They point out that all of the values given above for the P and S wave velocities of the New Madrid earthquake are high, especially the velocity of P_g.

McEvilly (1964) used Love and Rayleigh wave phase velocities in the period range 5 to 80 seconds to determine a shear wave model for a region of the Central United States. The table below indicated the crustal model which he obtained.

After McEvilly (1964)

Layer No.	H(km)	α(km/sec)	β(km/sec)	ρ(g/sec)
1	11	6.1	3.5	2.7
2	9	6.4	3.68	2.9
3	18	6.7	3.94	2.9

He also obtained models for the upper mantle, but they are not pertinent to this study.

Due to the importance of the Mississippi Embayment as a seismically active area, it will be of great help for future seismic studies of the region if average velocity models can be established for both compressional and shear waves. This will be important preliminary information for accurate earthquake locations and depth determinations, and as a starting point for more detailed studies of the region.