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CRUSTAL STRUCTURE OF WEST-CENTRAL NEW MEXICO: A PRELIMINARY SEISMIC INTERPRETATION

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Abstract—A new, unreversed seismic profile was recorded in the region from Socorro to Datil, New Mexico in June 1993. These data, when interpreted in the context of previously existing data, provide a new picture of the transition zone between the Colorado Plateau and Rio Grande rift in western New Mexico. Crustal structure characteristic of the rift extends at least as far west as Magdalena, New Mexico before the crust appears to gradually thicken into the Colorado Plateau. This broad transition zone is generally similar to that found in recent studies of the boundary between the Basin and Range province and Colorado Plateau in western Arizona.

INTRODUCTION

As part of the University of Texas at El Paso's ongoing investigations of crustal structure in the Rio Grande rift region, our group has been recording seismic refraction data along a profile extending between the White Sands Missile Range (WSMR), New Mexico, and the Nevada Test Site (NTS). As part of this effort, we deployed a seismic array in June 1993 to record the Minor Uncle conventional surface explosion at WSMR. Sixty-eight stations were deployed at 1 mi intervals along US Highway 60 beginning 4 mi west of Socorro, New Mexico, and ending 10 mi west of Datil, New Mexico (Fig. 1). Each station consisted of a 1 Hz, vertical component seismometer and a USGS Seismic Cassette Recorder (SCR). The Minor Uncle experiment went off as scheduled and 61 SCRs recorded a strong signal. The resultant record section shows excellent signal-to-noise ratios and exhibits several prominent arrivals (Fig. 2). Taken alone, this unreversed profile would be of limited utility. However, when combined with other seismic data in the region it provides a useful constraint on crustal structure in the area. In this paper, we present a preliminary interpretation of these new data and update our analysis of regional crustal structure. We hope to gather additional data along this profile over the next few years.

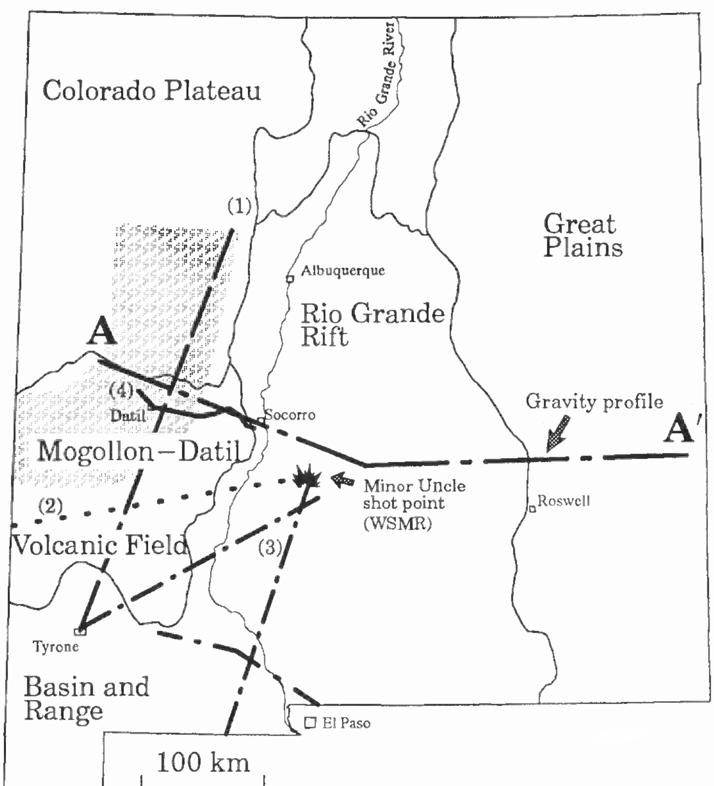

FIGURE 1. Index map of New Mexico showing locations of seismic profiles and geophysical models. 1 - Seismic profile of Schneider and Keller (in press); 2 - seismic profile of Jaksha (1982); 3 - seismic profiles of Sinno et al. (1986); 4 - seismic profile of this study. Shaded area is the zone of transition in crustal structure of Schneider and Keller (in press) as modified in this study. Profile A-A' represents the gravity data modeled in Figure 5.

PREVIOUS WORK

Previous surveys in the region have helped to constrain our seismic model. Sinno et al. (1986) conducted a series of seismic surveys in the southern Rio Grande rift utilizing explosions at WSMR and at the copper mines near Tyrone, New Mexico (Fig. 1). Their reversed NE-SW trending profile indicated a relatively flat Moho at a depth of 32 km between Tyrone and the northern portion of WSMR, with a slight increase in the depth to the Moho to the southwest.

Jaksha (1982) monitored another WSMR explosion with a widely spaced seismic array extending westward from WSMR to Morenci, Arizona. He reversed his profile by recording blasts from the copper mine at Morenci, and interpreted his results in terms of flat-lying horizontal layers. These data were reinterpreted by Schneider (1990) and Keller and Schneider (in press) who combined the Jaksha (1982) data with their seismic and gravity data gathered along a profile extending from Tyrone to Grants, New Mexico. These two profiles cross in the

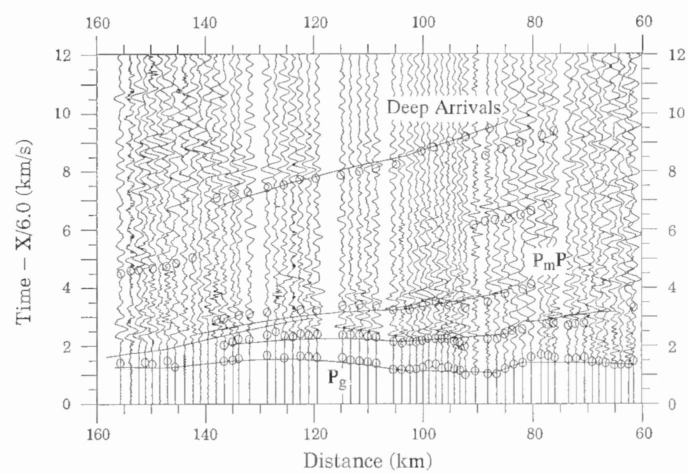

FIGURE 2. Seismic record section of the Minor Uncle data. The picked arrival times of the main phases modeled are identified by circles and the modeled arrival times are shown as the line. These arrivals are also shown in Figure 4 and are explained in the text.

central portion of the Mogollon-Datil volcanic field. They used two-dimensional modeling techniques to interpret the new seismic and gravity data and to reinterpret Jaksha's data. Their work indicated the presence of an upper crustal intrusive complex beneath the Mogollon-Datil volcanic field (MDVF) and under at least part of the San Agustin plains, as well as a mostly gradual south to north thickening of the crust (Fig. 3). Their analysis suggests a gradual crustal transition between the Colorado Plateau and the Rio Grande rift which extends under the MDVF (Fig. 1).

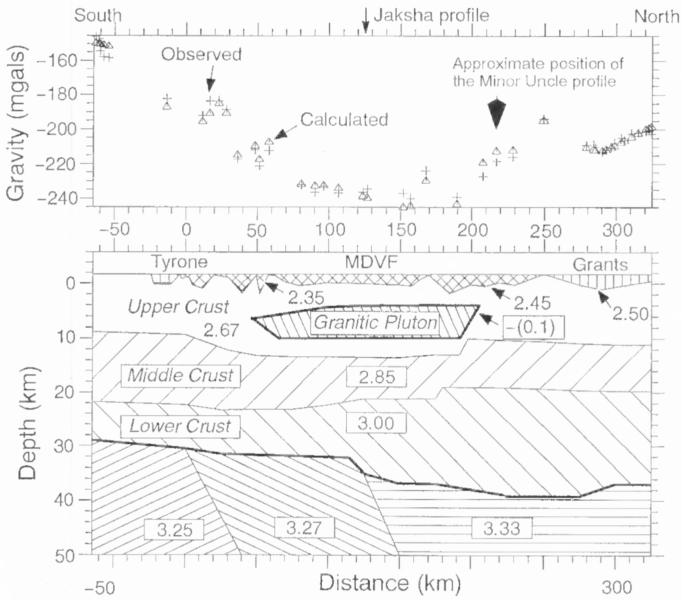

FIGURE 3. Earth model derived by Schneider and Keller (in press) for the Tyrone to Grants profile (Fig. 1). Numbers indicate densities in g/cc. Modified from Schneider and Keller (in press).

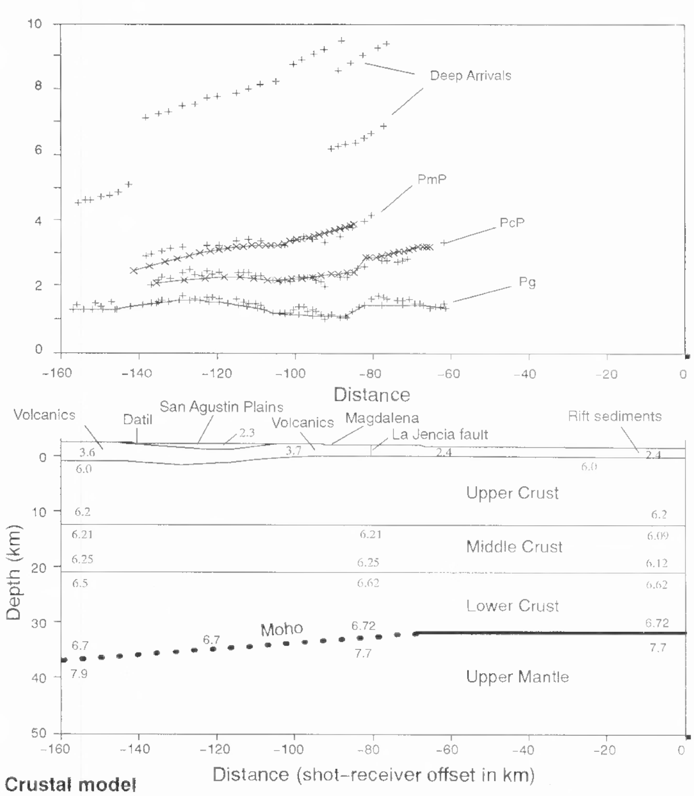

FIGURE 4. Picked arrival times (from Fig. 2) and preliminary earth model derived from ray tracing the Minor Uncle seismic data. Numbers indicate P-wave velocities in km/s.

Adams and Keller (in press) investigated crustal structure in central New Mexico by integrating seismic, gravity and geologic data. They delineated the general basin structure of the region and found that the transition in crustal structure from the Rio Grande rift to Colorado Plateau across the Datil region was gradual.

DISCUSSION

The data presented here complement the previous studies in the area. The seismic record section (Fig. 2) shows clear phase arrivals for P_g (refraction from the upper crust), P_cP (reflection from the middle crust), and P_mP (reflection from the Moho). A P_n (refraction from the upper mantle) arrival is also present on the westernmost traces. Each of these phases were modeled by ray tracing employing the previous work of Sinno et al. (1986) and Schneider and Keller (in press) as independent constraints. A preliminary earth model is shown in Figure 4.

With a maximum source-receiver offset of 155 km, these data do not provide any constraint on the upper mantle velocity structure and contain only a limited amount of information on the structure of the crust/mantle transition. However, these data do suggest that the relatively thin crust (~ 32 km) interpreted by Sinno et al. (1986) within the central part of the rift extends westward to an offset of at least 70 km in this survey. This is approximately the position of the La Jencia fault (Fig. 4). The seismic profile of Schneider and Keller (in press) shows that the crustal thickness is about 38 km at Datil, and thus requires the westward increase in Moho depth shown in Figure 4.

The shallow crustal features in Figure 4 are noticeably simplistic due to the lack of fine resolution contained in the data. Each of the crustal phases, especially the P_g arrival, are affected by several shallow velocity contrasts. The largest contrasts are associated with the transition from thick, central-rift, basin-fill sediments in the east to Tertiary volcanic sequences and thin basin-fills in the west; and the subsidence and sedimentation that form the San Agustin plains. The first transition occurs at a source-receiver offset of approximately 80 km and shows up as a sharp decrease in phase arrival time with increasing offset. This transition is located just east of the Magdalena Mountains at the basin-bounding La Jencia fault. The San Agustin plains show up as a broad travel time delay centered at an offset of 130 km. This anomaly was modeled with approximately 1 km of basin sediments and a slight thickening of the volcanic sequences to the west. No compelling evidence for an upper crustal batholith was found, nor was expected based on the interpreted extent of the Mogollon-Datil batholith presented by Schneider and Keller (in press). Two other regions of the section indicate the presence of shallow crustal features that have not been incorporated into the model at this time. Two subtle phase arrival delays are present between 70 and 80 km (Figs. 2, 4). These are interpreted to be associated with the sediments of the La Jencia basin in the west and the Socorro basin in the east, which are separated from each other by the Socorro-Lemitar Mountains. West of the La Jencia fault (at approximately 100 km offset), a third phase delay is interpreted as the Abbey Springs basin sediments (R. Chamberlin, personal commun., 1994).

These data also indicate one and possibly two deep phases arriving significantly later than the crustal phases (Fig. 2). The timing of these arrivals is inconsistent with a P_mP crustal multiple but can be fitted with a west-dipping reflector in the upper mantle. The data suggest that there may be at least two such upper mantle reflectors.

In order to place these results in a regional context, a crustal model that crosses the state of New Mexico was constructed by gravity modeling (Fig. 5). This model is consistent with the seismic results presented here, and corroborates the conclusions of Schneider and Keller (in press) that the transition in crustal structure between the Rio Grande rift and the Colorado Plateau occurs over a broad region in western New Mexico. This model also illustrates our interpretation that the eastern (Roberts et al., 1991) and western margins of the rift are quite different, with the change in structure across the western margin being more gradual.

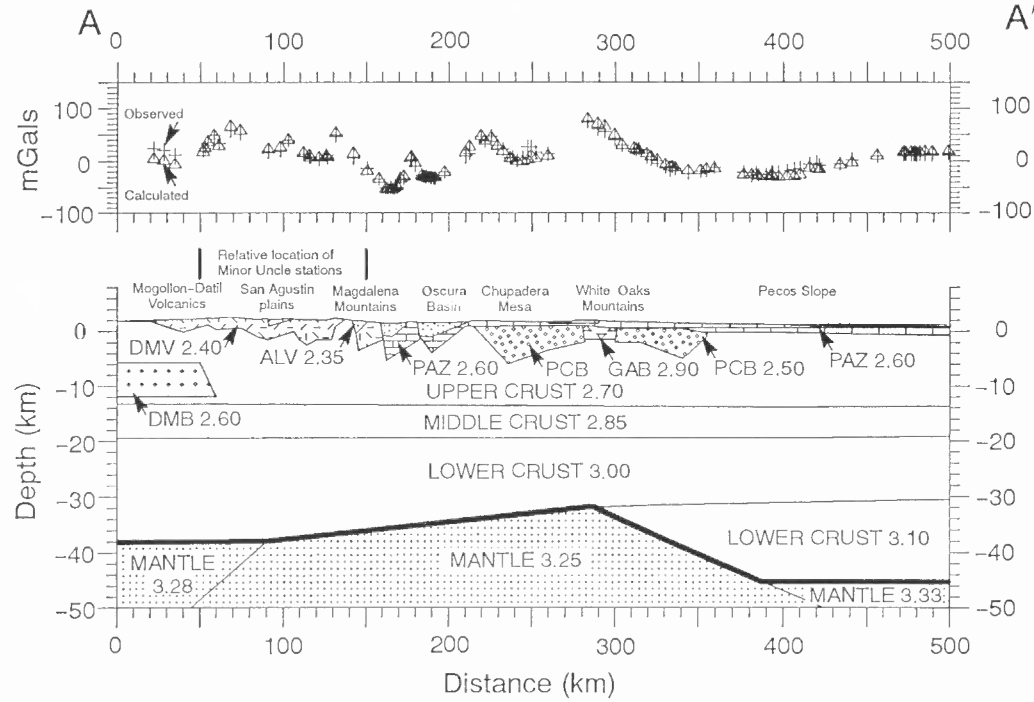

FIGURE 5. Free air gravity model across New Mexico (A-A', Fig. 1). This model is constrained by deep petroleum exploration wells and the results of seismic refraction modeling of Roberts et al. (1991), Sinno et al. (1986), and Olsen et al. (1979). MDV - Mogollon-Datil volcanics, MDB - Mogollon-Datil batholith, ALV - Alluvium, PAZ - Paleozoic, PCB - Possible Precambrian or Paleozoic basin, GAB - Gabbroic intrusion.

CONCLUSIONS

The transition zone from the Rio Grande rift to the Colorado Plateau in western New Mexico is gradual in terms of crustal structure. However, thin crust associated with the rift extends westward to about the location of Magdalena, New Mexico. The preliminary crustal model shown in Figure 4 is similar to recent results across the transition zone between the Basin and Range province and Colorado Plateau in western Arizona (Jill McCarthy, personal commun., 1994), but needs further constraints to the west. Our future investigations will focus on a more detailed investigation of the seismic data shown here and on the underlying causes for variations in crustal structure along the margins of the Colorado Plateau and Rio Grande rift.

ACKNOWLEDGMENTS

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