MESF CYBER GEOSCIENCE JOURNAL ,November 2003

CRUSTAL THICKNESS MAP OF THE ARABIAN PLATE FROM SEISMIC DATA

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ABSTRACT

Compilation of crustal thickness map is achieved from published seismic refraction, surface and body waves data. The inclusion of surface and body waves results in a more uniform coverage of the earth's surface than is possible by using only the published refraction data.

The crustal thickness data are contoured. The constructed map shows thickening of the crust from the Red Sea and Gulf of Aden toward the east and north reaching maximum value at Zagros mountain belt. Also, thick crust is noticed at the center of the Arabian plate of 43-km. Recommendations for improvement in form and content will be welcomed.

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INTRODUCTION

A. Mohorovicic who made a study of the seismometric recordings of a Kulpa valley earthquake in Yugoslavia first discovered the boundary between the earth's crust and mantle. Mohorovicic concluded that at depth of some tens kilometers, there exists an abrupt change in velocities of longitudinal and secondary waves. In regions where the Moho discontinuity is distinct, longitudinal wave velocities increases from approximately 6.5 km/sec in the upper crust to approximately 7.6 - 8.4 km/sec in the upper mantle [1]. When the discontinuity is not clearly defined, the crust - mantle boundary is a transition zone, and the Moho depth is uncertain.

A great number of investigations relating to the determination of the depth of the Moho have been performed during ninety years since Mohorovicic pioneering work. The principle methods used for these investigations were seismological and gravitational methods.

The determination of the crustal thickness by seismic methods is far from being a standard procedure. Considerable interpretation of the seismic records is necessary to derive the depth to, and the longitudinal wave velocity (Pn) for, the top of the mantle. Even then, the seismic thickness is not necessarily the only measure of the crust. Considerations of gravity crust, crustal rigidity and heat flow yields a crust that is typically much thicker than the seismic crust. In this paper, we were concerned with the seismic crust.

Soller et al., [1] used an up-to-date global compilation of crustal thickness and Pn velocity values from published seismic refraction and surface wave data to construct the global isopach map of the earth's crust. Regionally, Dehgani and Makris [2] used gravity data to construct a crustal thickness map beneath Iran. AlBanna and Al-Heety [3] constructed a crustal thickness map beneath Iraq using gravity data.

The purpose of this paper is a construction of the crustal thickness map beneath the Arabian plate using the available crustal thickness results obtained from seismic data.

SELECTION AND EVALUATION OF DATA

A literature search was conducted for crustal thickness data derived from seismic refraction, surface and body waves studies beginning with a review of previous global, regional and local compilations. Additional references were gathered from review of journals indices.

When the published results of a given refraction surveys were presented in several articles, only one reference, was selected to represent each survey. All crustal thickness data points, indexed by reference number, and are shown in Figure 1.

The quality of data presentation in the surveyed literature was variable, necessitating a judgment as to which sources provided reliable data, consistent with neighboring values and which did not. A source was judged acceptable if thickness values and locations were clearly determinable.

Source data were not reinterpreted, but when points of crustal thickness determination were lacking, the source was systematically treated, inorder to assign data to a specific point on the earth's surface. Thicknesses were rounded off to nearest kilometer.

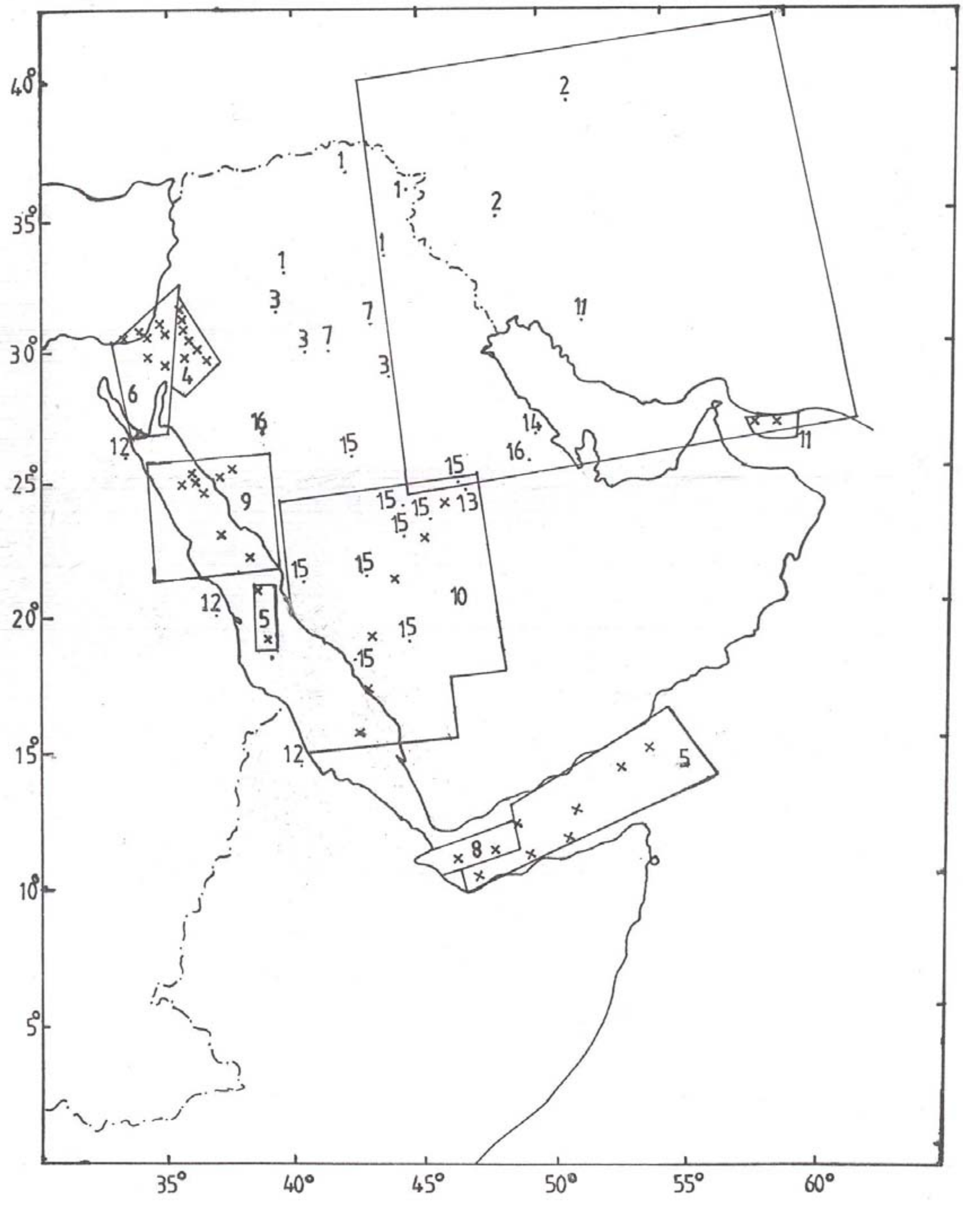

Figure 1. Index map of data points and corresponding reference number.

In surface wave studies, the midpoint between focus and the recording station, or between the recording stations, was selected as a location of the seismic station was selected as the data point.

Data coverage is generally sparse, but in some areas the data are sufficiently. Thickness values that deviated by more than 10km from adjacent values were disregarded.

The clarity of data presentation in the published source was also considered, because clearly presented results are less ambiguous and therefore more reliable. For example, data presented in tabular form was preferred to a cross- section along a vaguely defined traverse.

DATA PRESENTATION AND INTERPRETATION

An isopach map of the crust beneath the Arabian plate was generated by manually contouring with contour interval of 5km (Figure 2). When interpreting this map, it is extremely important to pay close attention to the data point distribution. Contour accuracy is directly related to data density, therefore a measure of reliability may be obtained by examining the data distribution.

This map agrees with conventional geophysical ideas. Many tectonic features are recognizable on the map as localized thickness variations, and they deserve notice. The map showed thickening of the crust beneath Zagros Mountain Belt, western and eastern Arabian platform.

Beneath the principle trough of the Red Sea, the crust may be continental type and of oceanic type beneath the axial trough of the Red Sea. The crust beneath Gulf of Aden is of oceanic type.

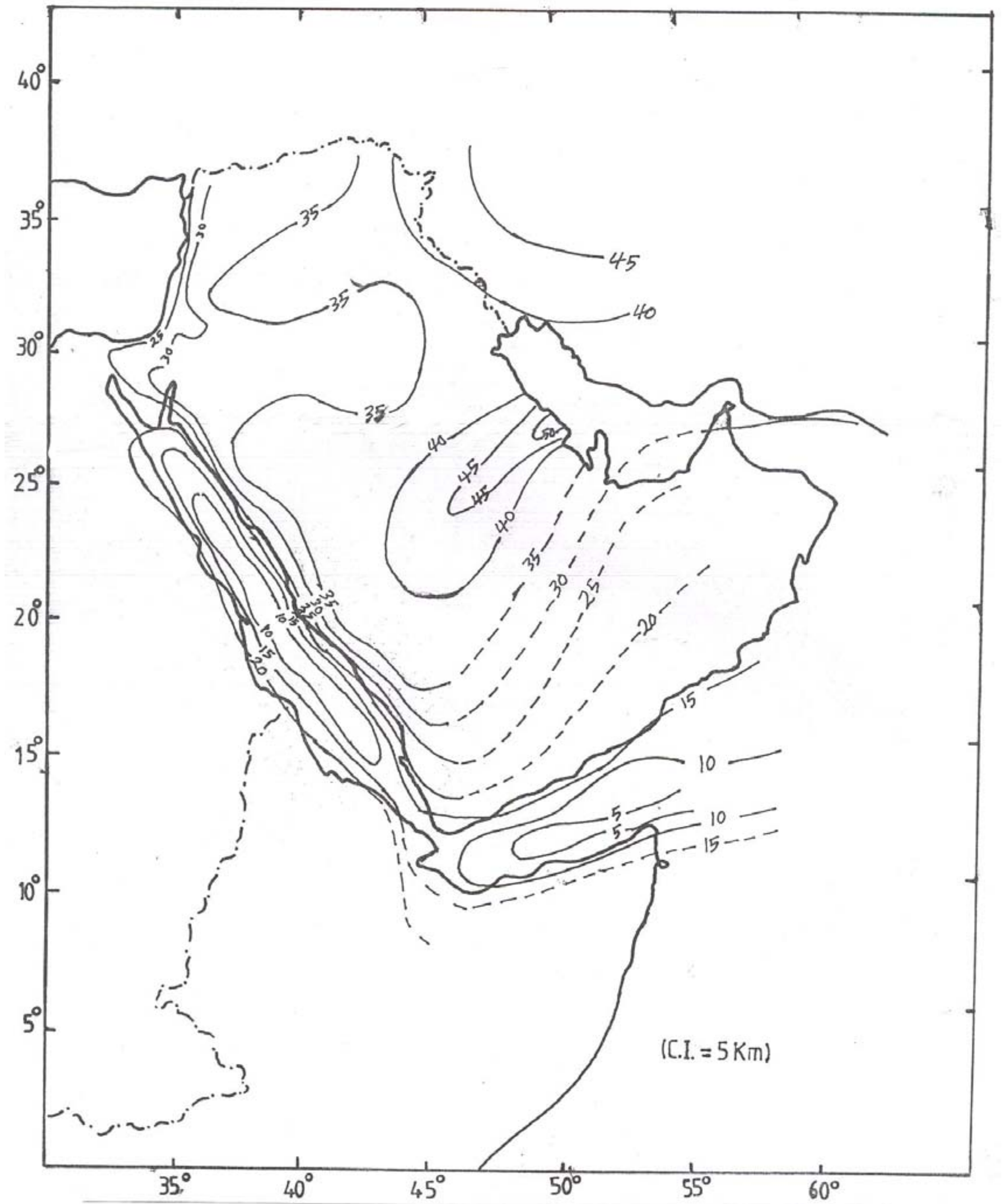

Figure 2. Isopach map of the earth's crust. The dashed lines were extrapolated

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These results are in a good agreement with results of other geophysical studies (e.g. [20], [21]). These studies suggested that the crust beneath the principle trough of the Red Sea might be of continental type and presence of oceanic crust beneath the axial trough of southern Red Sea, Gulf of Aden and Afar region.

REFERENCES

[1] D.R. Soller, R.D. Ray,and R.D. Brown," A New Global Crustal Thickness Map", Tectonic, 1(1982),P. 125.

[2] G. Dehgani and J. Makris, " The Gravity Field and Crustal Structure of Iran", N. Jb. Geol. Palaont Abh. (Stuttgart) 168(1984), P. 215.

[3] A.S. AlBanna and E. A. Al-Heety," Crustal Thickness Map of Iraq Deduced from Gravity Data", Iraqi Journal of Sciences 35(1996), P. 749.

[4] S.A. Alsinawi and E.A. Al-Heety, " Crustal Thickness Determination of Iraq from Long Period P- Wave Spectra", Iraqi Geological Journal 25(1994), P. 28.

[5] I. Asudeh," Seismic Structure of Iran from Surface and Body wave Data", Geophys. J. R. Astr. Soc., 71(1982), P. 715.

[6] M. Dahham and Z. Mohammed," A Crustal Model for Iraq and Northern Arabian Peninsula from Dispersed Rayleigh Waves", ABHATH AL-YARMOUK : ((Pure Sci. & Eng.)) 2(1993), P. 119.

[7] Z. El - Isa, J. Mechie and C. Prodehl," A Crustal Structure Study of Jordan Derived from Seismic Refraction Data", Tectonophysics , 138(1987),P.235.

[8] J.D. Fairhead," Crustal Structure of the Gulf of Aden and the Red Sea",

Tectonophysics, 20(1973),P. 261.

[9] A. Ginzburg, J. Makris, K. Fuchs, C. Prodhle, W. Kaminiski and U. Amitai," A Seismic Study of the Crust and Upper Mantle of the Jordan - Dead Sea Rift and Their Transition Towards the Mediterranean Sea", J. Geophys. Res., 84(1979), P. 1569.

[10] L. Knopoff and A. Fouda," Upper Mantle Structure Under the Arabian Peninsula", Tectonophysics, 26(1975),P. 121.

[11] A.S. Laughton and C. Tramontini," Recent Studies of Crustal Structure in the Gulf of Aden", Tectonophysics, 8(1969),P. 359.

[12] J. Makris, A. Allam, T. Mokhtar, A. Basahel, A. Dehgani and M. Bazari," Crustal Structure in the Northwestern Region of the Arabian Shield and its Transition to the Red Sea", Bull. Fac. Earth Sci., King Abdulaziz University, 6(1983),P. 435.

[13] W.D. Moony, M.E. Gettings, H.R. Blank and J.H. Healy," Saudi Arabian Seismic - Refraction Profile: A Travel Time Interpretation of Crust and Upper Mantle Structure", Tectonophysics, 111(1985),P. 173.

[14] M. Niazi," Microearthquakes and Crustal Structure of the Makran Coast of Iran", Geophys. Res. Lett., 7(1980),P. 297.

[15] A. Al - Amri," The Crustal Structure of the Western Arabian Platform from the Spectral Analysis of Long - Period P - Wave Amplitude Ratios", Tectonophysics, 290(1998),P. 271.

[16] A. Al - Amri," The Crustal and Upper Mantle Structure of the Interior Arabian Platform", Geophy. J . Int., 136(1999), P. 421.

[17]A. Al - Amri and A. Gharib," Lithospheric Seismic Structure of the Eastern Region of the Arabian Peninsula", Journal of Geodynamic,29(2000),P.125.

[18] E. Sandvol, D. Seber, M. Barazangi, F. Vernon, R. Mellors and A. Al - Amri," Lithospheric Velocity Discontinuities Beneath the Arabian Shield", Geophys. Res. Lett., 25(1998),P. 2873.

[19] A. Rodgers, W. Walter, Y. Zhang, R. Mellors and A. Al - Amri," Lithospheric Structure within the Arabian Peninsula from Complete Regional Waveform Modeling and Surface Wave Group Velocities", Geophys.J. Int., 138(1999),P. 871.

[20] P. Moher,' The Afar Triple Junction and Sea Floor Spreading", J. Geophy. Res., 75(1970),P. 7340.

[21] J. Cochran," A Model for Development of Red Sea", AAPG Bull., 67 (1983),P. 41.

الخلاصة

أنجزت خارطة لسمك القشرة الأرضية للصفيحة العربية من المعلومات الزلزالية المنشورة (الانكسار ، الزلزالي، والموجات السطحية والموجات الجسمية). ينجم عن استخدام معلومات الموجات السطحية والجسمية تغطية اكبر لسطح الأرض مقارنة باستخدام معلومات الانكسار الزلزالي المنشورة فقط.

رسمت بيانات سمك القشرة بشكل خطوط كنتورية. أظهرت الخارطة زيادة في سمك القشرة الأرضية من البحر الأحمر وخليج عدن باتجاه الشرق والشمال، حيث وصل إلى أقصى قيمة عند نطاق جبال زاكروس. كذلك لوحظت قشرة سميكة عند مركز الصفيحة العربية، حيث وصل السمك إلى حوالي 43 كم.ويرحب الباحث بالتوصيات والملاحظات التي تساهم في تحسين الخارطة المنجزة من حيث الشكل والمحتوى.