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Subject: Quarterly Progress Report - October, November, December, 1980 on Contract No. NAS5-22816

Date: December 29, 1980

During the first quarterly report period progress has been initiated on most aspects of the program. We have tested and modified as necessary our spherical earth inversion, modeling and contouring software for processing data in the southern hemisphere. The performance of our modeling program SPHERE in low and southern magnetic latitudes is illustrated in Figure 1. The magnetic anomaly fields calculated are due to a 6.67 km thick prism with magnetic susceptibility contrast equal to 0.0005 emu/cm^3 located 6.67 km below the observation grid with interval spacing equal to 6.67 km. The prism anomaly computations for positive and negative geomagnetic field inclinations are presented in Figures 1.A and B, respectively. In Figure 1.C the prism anomaly calculated in a horizontal geomagnetic field is given.

Preliminary geologic/tectonic maps and selected cross-sections for South and Central America and the Caribbean region are being compiled. Gravity and magnetic models for major geologic features of the study region are being prepared for comparison with the MAGSAT data. In Figure 2 is presented a preliminary gravity model of the Andean Benioff Zone. This model has been constructed so that the density columns east and west of the subducted plate are in approximate isostatic equilibrium. The density values are taken from the seismic refraction studies of Worzel (1976) and Meyer et al. (1976).

The corresponding magnetic model is given in Figure 3. The Curie temperature of magnetite (≈ 580°C) was used as the magnetic basement (Kristjansson and Watkins, 1977). Toksöz's (1971) model was used to define the 580°C isotherm for a young crust at an 8 cm/yr spreading rate. The magnetization values given in this model are very preliminary and were adopted principally to obtain a first order estimate of the anomaly signature at 350 km elevation for comparison with the MAGSAT data. The magnetic anomaly for this model currently is being computed using program SPHERE.

A test tape of Investigator B data containing global MAGSAT measurements for November 6 & 7, 1979 was obtained from NASA-GSFC in mid-November, 1980. This tape was not formatted according to our original specifications and, hence,

(E81-10115) [GRAVITY AND MAGNETIC ANOMALY MODELING AND CORRELATION USING THE SPHERE PROGRAM AND MAGSAT DATA] Quarterly Progress Report, Oct. - Dec. 1980 (Purdue Univ.) 7 p HC A02/MF A01 CSCL 08G
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had to be converted to a tape format compatible with Purdue's CDC system. We recently completed this conversion and currently are processing the tape for data pertinent to our investigation.

NOO project MAGNET data are being processed for verification of the MAGSAT data. The NOO data have been screened for periods of high diurnal activity and reduced to anomaly form using the updated IGS-75 field model. The total magnetic intensity anomaly profiles have been high-cut filtered utilizing a 50% cut-off at 200 km wavelength. The observed and high-cut filtered anomaly profiles have been plotted on the conterminous U.S. map using the track lines as the anomaly base level. A contour map derived from the high-cut filtered profiles currently is being compiled. This map will then be digitized and upward continued by equivalent point source inversion to 350 km elevation for comparison with the MAGSAT data. Preliminary results show that the transcontinental magnetic high which is a prominent feature of both the POGO and MAGSAT data is also represented in the NOO data.

A number of papers have been prepared for publication in scientific journals. These include manuscripts on spherical earth gravity and magnetic anomaly analysis, spherical earth gravity and magnetic anomaly modeling, and regional North American gravity and magnetic anomaly correlations. The abstracts for these papers are given in Appendices A, B and C, respectively. In addition a fourth paper was presented at the 1980 Midwest AGU Meeting (Northern Illinois University, DeKalb, IL) on gravity and magnetic anomaly modeling of Mississippi Embayment crustal structure at satellite elevations. The abstract for this paper is given in Appendix D.

References

Kristjansson, L. and N.D. Watkins, Magnetic studies of basalt fragments recovered by deep drilling in Iceland and the "magnetic layer" concept, Earth Planet. Sci. Lett., 34, 365-374, 1977.

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Toksöz, M.N., Temperature field and geophysical effects of a downgoing slab, J. Geophys. Res., 76, 1113-1138, 1971.

Worzel, J.L., Gravity investigations of the subduction zone, Amer. Geophys. Union Monogr., 19, 1-15, 1976.

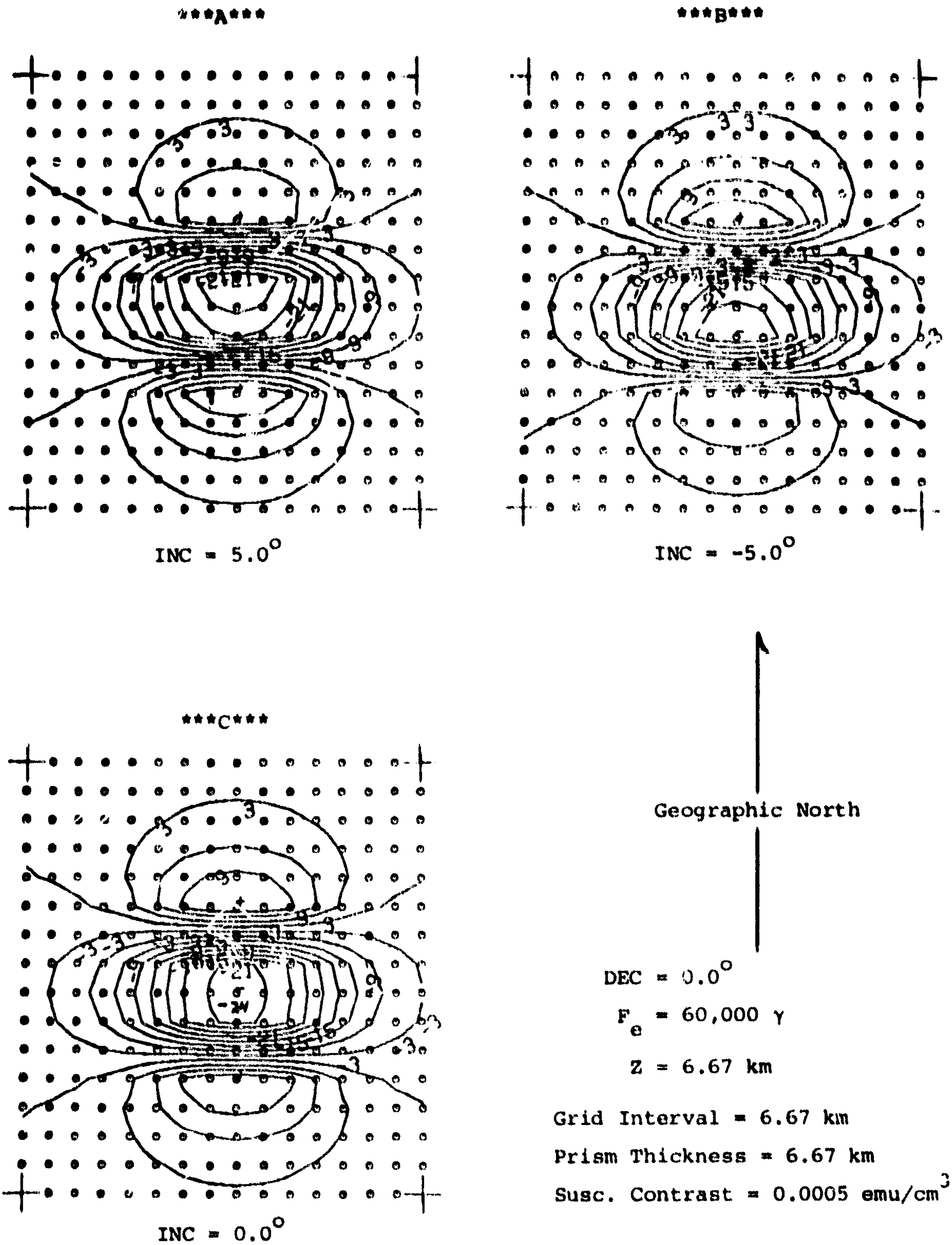

Figure 1. Magnetic prism anomaly calculations at low geomagnetic latitudes.

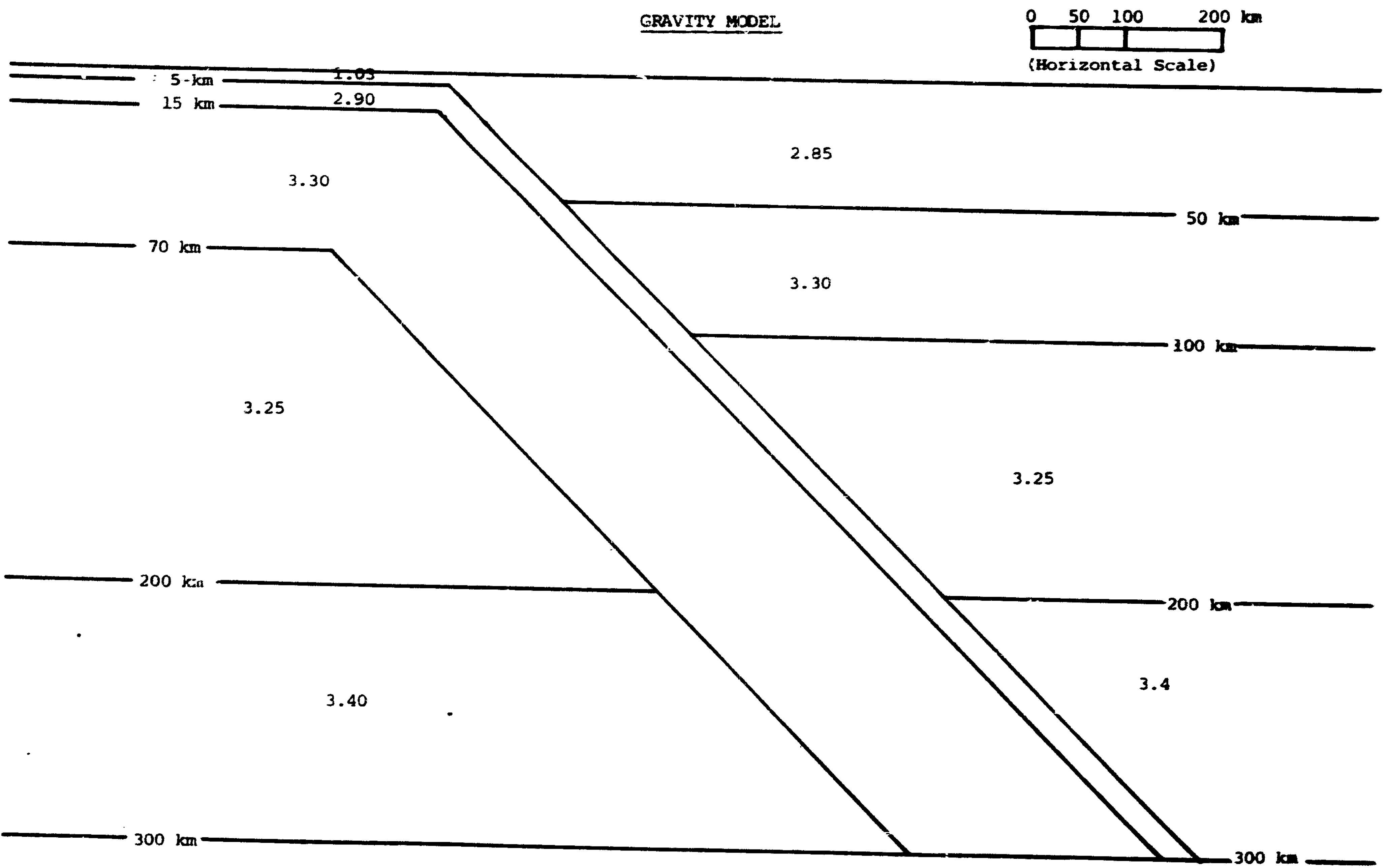

Figure 2. Gravity model of Andean Benioff Zone. Density values are in g/cm^3 units.

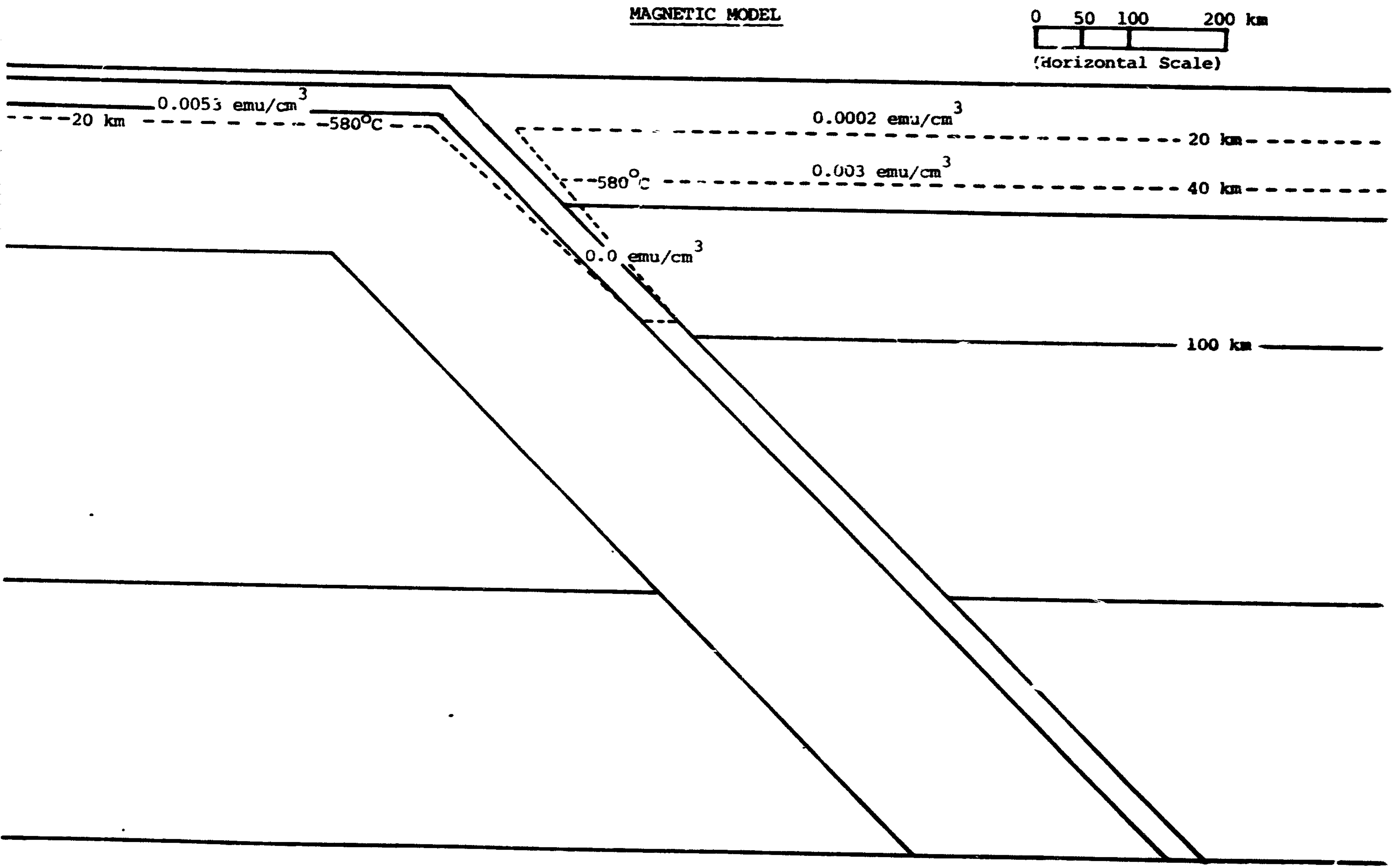

Figure 3. Magnetic model of Andean Benioff Zone.

APPENDIX A

SPHERICAL EARTH GRAVITY AND MAGNETIC ANOMALY ANALYSIS BY EQUIVALENT POINT SOURCE INVERSION

To facilitate geologic interpretation of satellite elevation potential field data, analysis techniques are developed and verified in the spherical domain that are commensurate with conventional flat earth methods of potential field interpretation. A powerful approach to the spherical earth problem relates potential field anomalies to a distribution of equivalent point sources by least squares matrix inversion. Linear transformations of the equivalent source field lead to corresponding geoidal anomalies, pseudo-anomalies, vector anomaly components, spatial derivatives, continuations, and differential magnetic pole reductions. A number of examples using 1^{o}-averaged surface free-air gravity anomalies and POGO satellite magnetometer data for the United States, Mexico and Central America illustrate the capabilities of the method.

In press, Earth Planet. Sci. Lett., 1981

APPENDIX B

SPHERICAL EARTH GRAVITY AND MAGNETIC ANOMALY MODELING BY GAUSS-LEGENDRE QUADRATURE INTEGRATION

The utility of long-wavelength potential field anomalies to lithospheric interpretation is greatly increased with spherical earth modeling techniques. Gauss-Legendre quadrature integration is used to calculate the anomalous potential of gravity and magnetic fields and their spatial derivatives on a spherical earth for an arbitrary body represented by an equivalent point source distribution of gravity poles or magnetic dipoles. The distribution of equivalent point sources is determined directly from the coordinate limits of the source volume. Variable integration limits for an arbitrarily shaped body are derived from interpolation of points which approximate the body's surface envelope. The versatility of the method is enhanced by the ability to treat physical property variations within the source volume and to consider variable magnetic fields over the source and observation surface. A number of examples verify and illustrate the capabilities of the technique, including preliminary modeling of potential field signatures for Mississippi Embayment crustal structure at satellite elevations.

In press, J. Geophys., 1981

APPENDIX C

REGIONAL NORTH AMERICAN GRAVITY AND MAGNETIC ANOMALY CORRELATIONS

Correlation of gravity and magnetic anomalies combined with other geological and geophysical data is useful for enhancing the quality and uniqueness of the geological interpretation of potential anomaly fields. Maps produced by equivalent point source inversion are used to investigate qualitative visual-spatial correlations of surface free-air gravity and POGO satellite magnetic anomalies and regional heat flow and tectonic data for North America and adjacent marine areas. A more quantitative analysis of the regional potential field anomaly correlations at satellite elevations also is considered utilizing Poisson's theorem in a moving-window linear regression analysis between appropriate derivatives of the anomalous gravity and magnetic fields.

An inverse relationship is observed qualitatively and quantitatively between long-wavelength gravity and magnetic anomalies over continental terrane. Regional correlations of negative gravity and positive magnetic anomalies characterize areas of large relative crustal thickness and magnetization. An example is a prominent magnetic high which corresponds to a gravity minima trend extending from the Anadarko Basin to the Cincinnati Arch. Negative magnetic and positive gravity anomalies characterize thinner crust and regions of higher heat flow such as the Cordillera of North and Central America and specifically the Yellowstone geothermal region. Although gravity and magnetic anomalies over oceanic areas show limited correlation, statistically the sign of the correlation generally is positive.

Submitted, Geophys. J.R. Astr. Soc., 1981

APPENDIX D

MISSISSIPPI EMBAYMENT CRUSTAL STRUCTURE FROM SATELLITE ELEVATION GRAVITY AND MAGNETIC ANOMALY DATA

A model for the three-dimensional crustal structure of the northern Mississippi Embayment is generalized from published surface wave dispersion, and seismic refraction studies. The gravity and magnetic anomaly signatures of this four-body model are computed at 450 km elevation by Gauss-Legendre quadrature integration for comparison with observed anomalies at satellite elevations. The computed positive gravity anomaly compares well with upward continued free-air gravity data suggesting that the generalized model is representative of the crustal structure of the Embayment. Magnetic anomaly calculations show that the pronounced minimum observed over the Embayment in the POGO satellite magnetometer can be accounted for by a decrease in the magnetization of the lower crust which corresponds to the major gravity source of the region. The results of this investigation support the failed-rift hypothesis for the origin of the Mississippi Embayment. Accordingly, these results suggest that observable gravity and magnetic anomalies characterize failed rifts (aulacogens) at satellite elevations, where the primary source of both anomalies is a high density rift component of non-magnetic lower crustal material.

EOS (Am. Geophys. Union Trans.), V. 61, p. 1195, 1980.