March 10, 1993

Gloria Blanchard
Grants Officer
Procurement Office
NASA
Goddard Space Flight Center
Greenbelt, MD 20771

ATTN: 286.1

SUBJECT: NASA GRANT NO. NAG 5-842, CIT NO. 64672

Enclosed please find the Final Technical Report for NASA Grant NAG 5-842 "Intraplate Deformation, Stress in the Lithosphere and the Driving Mechanism for Plate Motions," covering the period through December 31, 1991. We apologize for the delay in submitting this report.

Sincerely,

Arden L. Albee
Principal Investigator

cc: B. Hager
Sponsored Research
Federal Accounting
Results from Crustal Dynamics Project-funded research

A. Main research directions

Bradford Hager has been an active participant in the Crustal Dynamics Project since its inception, with over 25 papers published or in press and over 40 talks at professional meetings supported by my grant. The initial research proposed was to use the predictions of geodynamical models of mantle flow, combined with geodetic observations of intraplate strain and stress, to better constrain mantle convection and the driving mechanism for plate motions and deformation. As discussed in the main body of the proposal, it is only now that geodetic observations of intraplate strain are becoming sufficiently well resolved to make them useful for substantial geodynamical inference to be made. In the interim, Dr. Hager has made substantial progress in geodynamical modeling of flow and stress in the mantle.

My main research accomplishment supported by this grant has been to develop a model of flow in the mantle that explains almost 90% of the variance in the observed longwavelength nonhydrostatic geoid (degree 2-9). In this model, flow is driven by density contrasts inferred from velocity variations imaged using body wave tomography of the lower mantle and surface wave tomography of the upper mantle, as well as density contrasts from a geophysical model of subducting slabs. The flow results in dynamic topography at the Earth's surface, the core-mantle boundary (CMB), and at any interior compositional boundaries that are included in the model (e.g., the D' layer above the CMB, the 670 km discontinuity). This dynamic topography, which is a strong function of the viscosity and compositional structure of the mantle, has an influence on the geoid comparable in amplitude and opposite in sign to that of the driving density contrasts. By a forward modeling procedure, we arrive at the mantle structure that gives a predicted geoid that best matches the observed geoid. Constraints on CMB topography are provided by the interpretation of nutation amplitudes (provided by other researchers supported by the CDP). This model has a low-viscosity asthenosphere, with an increase in viscosity of about a factor of 300 across the transition zone to a moderately high viscosity lower mantle. The implications of this model for postglacial rebound and stress at the base of the plates are discussed in the main body of the proposal.

Another important research direction has been a collaborative effort with Eugene Humphreys to understand the dynamics of the Big Bend region of the San Andreas fault in southern California. This work resulted in a high-resolution tomographic image of a curtain high velocity material beneath the Transverse Ranges. We interpret this to be a convective downwelling that provides dynamic support of the Transverse Ranges.

In an effort to better constrain the kinematics of this region, a multi-institutional group of researchers began a GPS program, sponsored by NSF and NASA CDP. Part of this project involved a footprint in the vicinity of the Santa Paula VLBI site in the Ventura Basin. After several surveys, spanning three years, we have resolved the horizontal velocity field in the vicinity of Santa Paula. The VLBI site is an area undergoing intense strain and rotation, with strain rates a factor of two higher than those associated with the San Andreas fault.
B. Papers published with CDP Support (abstracts excluded)


C. Ph. D. students supported (Caltech)

Eugene Humphreys: Studies of the crust-mantle system beneath southern California, 1985.


Shawn Larsen: Geodetic measurement of deformation in southern California, 1990.


D. Postdoctoral Fellow (Caltech)

Leslie Sonder, 1986-1988

E. Public service

Hager has been an active contributor to community activities associated with CDP, beginning with service on the original review panel. He was an active participant in both the Airlie House meeting and the Erice workshop. He was a member of the Program Panel for the Coolfont meeting. He is now serving on the Global Fiducial Network subcommittee of the NRC Committee on Geodesy.