THE CRUSTAL DYNAMICS PROJECT

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ABSTRACT. The Crustal Dynamics Project has been developing, deploying, and operating very-long-baseline interferometry (VLBI) systems and satellite laser ranging (SLR) systems for highly accurate geodetic measurements of global plate motion, plate stability, regional crustal deformation, and earth rotation/polar motion. Over the past 10 years, the measurement accuracies of these systems have been improved by a factor of 10 to the cm level. Plans are to continue these developments to reach mm level accuracies. The present deployment of the VLBI systems is primarily in the Northern Hemisphere. This network has produced measurements of the relative plate motion between the North American, Eurasian, and Pacific plates; the stability of the same plates; and the regional deformation at the North American/Pacific plate boundary in California and Alaska.

1. GEODETIC VLBI DEVELOPMENT

For the past 10 years, the National Aeronautics and Space Administration (NASA) has been the primary sponsor of the development of very-long-baseline interferometry (VLBI) for very accurate geodetic measurements over long distances. VLBI experiments, in the 1970s, demonstrated feasibility of the technique at the decimeter precision level. Next, the Mark III VLBI system was designed to provide improved accuracy for geodesy. By 1980, the Mark III system had been implemented in a few stations, and baseline measurement precisions of 5 cm had been achieved. At the same time, similar results had been obtained with satellite laser ranging (SLR) developments. Thus, NASA established the Crustal Dynamics Project (CDP) to further develop and implement geodetic VLBI and SLR for measurements of the deformations in the plate boundary regions in western North America; the contemporary relative plate motions of the North American, South American, Nazca, Eurasian, and Australian plates; the internal deformation of the plates, with emphasis on North America and Pacific; the rotational dynamics of the earth; and the regional deformations in other areas of high earthquake activity.

M. J. Reid and J. M. Moran (eds.), The Impact of VLBI on Astrophysics and Geophysics, 337–338.

The CDP developed several improvements in the VLBI system, and with the cooperation of many organizations in several countries, established a global VLBI network for crustal dynamics measurements. The current network measurements of baselines have a precision of about 1 cm. Further developments are under way with the goal of millimeter precisions in the future.

2. GLOBAL NETWORK FOR PLATE MOTION

The global network consists of fixed antennas equipped with the Mark III VLBI system. Some stations are dedicated geodetic stations, but most are multi-use stations scheduled occasionally for VLBI. The stations used for the CDP plate motion measurements are located on the North American Plate at Westford, MA, Ft. Davis, TX, Mojave, CA, Owens Valley, CA, Hat Creek, CA, and Fairbanks, AK; on the Pacific plate at Vandenberg, CA, Kokee Park, HI, and Kwajalein Is.; and on the Eurasian plate at Kashima, Japan, Onsala, Sweden, and Wettzell, FRG.

3. NORTH AMERICAN NETWORK FOR REGIONAL DEFORMATION AND PLATE STABILITY

For regional deformation and plate stability, the CDP uses the fixed stations, listed above, as base stations for measurements to mobile VLBI stations that occupy a large number of sites in the region to determine baselines crisscrossing the faults. The CDP developed two mobile VLBI stations which are deployed in western North America at sites located at Black Butte, CA, Deadman Lake, CA, Ft. Ord, CA, Mammoth Lakes, CA, Monument Peak, CA, Palos Verdes, CA, Pasadena, CA, Pearblossom, CA, Pinyon Flat, CA, Point Reyes, CA. Presidio, CA, Quincy, CA, Santa Paula, CA, Flagstaff, AZ, Yuma, AZ, Platteville, CO, Ely, NV, Vernal, UT, Cape Yakataga, AK, Kodiak, AK, Sand Point, AK, Sourdough, AK, Algonquin, Canada, Penticton, Canada, Whitehorse, Canada, and Yellowknife, Canada.

4. MEASUREMENT SCHEDULE

Since VLBI measures the vector baselines between two or more stations, repeated measurements over a period of time are needed to determine motions. The VLBI determination of velocities of centimeters/yr with a precision of millimeters/yr requires measurements to be made over several years.

The first measurements were started in 1980 with Westford, Ft. Davis, and Owens Valley in North America and Onsala in Europe. By 1983, the second European station was added at Wettzell, North American stations were added at Mojave, Vandenberg, and Hat Creek, and the two Mobile VLBI systems were deployed to many sites in California. The Pacific, Alaskan, and Canadian stations completed the network with measurements beginning in 1984. Thus, there are 3 to 6 years of measurements of these baselines. The CDP plans to continue these VLBI measurements for several more years in order to achieve the mm/yr precision in velocities of the sites.