Mapping small-scale crustal deformation of the western Transverse Ranges of southern California using paleomagnetic vectors and GIS; Preliminary results

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Abstract

The western Transverse Ranges (wTR) are located in southeastern California. The area begins approximately on the coast of California at Purissima Point and extends south to Long Beach and west to the San Andreas fault. The Channel Islands are part of the wTR because they are a partly submerged westward extension of the Santa Monica Mountains. This east-west orientation has been investigated extensively in the hopes of understanding the causes of unusual orientation. Geophysical research of the area has determined that indeed a 90-degree clockwise rotation has occurred.

Previously, numerous analyses of paleomagnetic data have used averages that resulted in masking the details of rotations and strains This assumes that the rotated region deformed uniformly; but in fact the paleomagnetic declination data shows variation indicating that this assumption is not completely valid.

High-resolution paleomagnetic, topographic and fault data are brought together within Arc/Info. This process avoids masking results that occurs with averaging the paleomagnetic vectors. The paleomagnetic data, site locations, and declinations of each site result are mapped using Arc/Info. Plotting each site location with the respective declination allows for a complete view of the range of crustal rotation and/or strain. Such plots may help to determine locations of crustal blocks and whether they have occurred by small or large crustal blocks as well as identify unknown faults.

The mapping of these units indicate that crustal blocks outlined by known faults generally have similar declinations allowing for secular variations. Significant variation in declination inside a block may indicate crustal blocks that have been deformed by folding or that additional unmapped faults may exist.

Introduction

The western Transverse Ranges trend east to west crosswise with respect to the northwesterly fabric of California. The San Andreas fault trends more east to west within the Transverse Ranges than elsewhere. This kink is known as the Big Bend. Simple north-south compression could have caused both the east-west folds and faults and the Big Bend in the San Andreas, but the source of such north-south compression remains a subject of speculation (Sharp, 1994).

The results of previous paleomagentic investigations by Bruce Luyendyk and other researchers as summarized by Luyendyk et al. (1985). (1) San Clemente, Santa Barbara, and San Nicolas islands have not rotated, whereas Santa Catalina Island has rotated ~100¡ clockwise. (2) The Northern Channel Islands have rotated clockwise 70¡ to 80¡. (3) The Santa Ynez Range has rotated clockwise ~90¡. (4) Crustal blocks between the San Gabriel and San Andreas faults has rotated clockwise ~35¡.

The purpose of our study is to map these patterns of crustal deformation using existing paleomagentic and fault data with a digital elevation model in order to determine locations of crustal rotations as well as identify unknown faults.

Data Acquisition

7.5 digital elevation maps (a.k.a. 30-meter DEMs) of the western Transverse Ranges were downloaded from California State University, Northridge s California Geological Survey website. The California Geographical Survey is a digital database created and maintained by the employees and students of the Department of Geography at California State University Northridge. The data files contained in the DEMs were created by the United States Geological Survey. The 7.5-minute files are the highest resolution DEMs currently available for a major percentage of the U.S. The resolution is exactly 30 meters on the ground, which is approx. 1 arc second on the meridian. The data points are gridded on a Universal Traverse Mercator basis (UTM, easting and northing) rather than a geographical basis (longitude and latitude).

The 7.5-minute DEM data are produced in 7.5-by-7.5-minute blocks either from digitized cartographic map contour overlays or from scanned National Aerial Photography Program (NAPP) photographs. Four processes have been used to generate DEM data for 7.5-minute units. Only one of four processes has survived which is the interpolation from digital line graph (DLG) hypsographic and hydrographic data. All data now being generated use this process.

B.P. Luyendyk has a collective database of several hundred paleomagentic results from his work and that of others. The data has been collected for over twenty years. The collection process started in the spring 1979 in Kamerling s work and has continued recently to spring 1992. This paleomagnetic data consists of location in latitude and longitude, site number, rock type, geologic period and epoch, inclination, declination, date of sample, alpha 95 numbers, as well as kappa angle measurements.

Proprietary fault map data was acquired from the California Department of Conservation s Division of Mines and Geology. In 1994, Charles Jennings digitized the earthquake source information from the Division of Mines and Geology s Fault Activity Map of California and Adjacent Areas. Geologic fault times mapped are Historical, Holocene, Quaternary, and late Quaternary. The map was compiled and published at a scale of 1:750,000. Source point locations are uncertain by up to one kilometer. The information is not appropriate for site-specific fault location evaluation.

Data Processing

Selected DEMs of the WTR were merged together into an Albers-Equal Area projection map using Arc/Info. The existing paleomagnetic database was reconstructed to include only the WTR area. A topographic map with NAD83 datum was originally used in the collection of samples. The database was converted from Fox-Pro basic to Excel and finally to comma delimited text format. Comma-delimited text format is necessary to enter site location points into Arc/Info. Site locations were converted to NAD27 datum projection to register with the base DEM. Errors in earlier longitude and latitude location sites within the database were corrected. Paleomagnetic sample sites then registered with the DEM.

The WTR DEM with the paleomagnetic sites was brought into ArcView. The relevant paleomagentic data file was attached to the sites. Having the database attached to its specific site would allow for map queries. An additional field had to be added to the database file in order to account for the negative inclination sites. Paleomagentic declination vectors were introduced into ArcView as a new theme. Arrows symbolize the vectors, which are rotated according to the data contained in the declination field within the paleomagnetic database file.

Preliminary Data Interpretation and Conclusions

The mapping of these data indicates that crustal blocks outlined by known faults generally have similar declinations allowing for secular variation.

Significant variation in declination inside a block may be an indication of crustal blocks that have been deformed by folding or that perhaps-additional unmapped fault exist.

Recommendations

The preliminary data agrees with results of previous paleomagentic investigations by Bruce Luyendyk and other researchers, Luyendyk et al. (1985). However the ability to view all paleomagnetic vectors at once instead of the mean suggests that further investigations need to be done. Specifically because all vectors can be viewed with respect to their age and far better understood where the larger or smaller crustal deformations have occurred within these given lapses of time. High-resolution maps are needed to investigate specific locations where paleomagnetic, topographic, and fault data suggest unknown faults as well as crustal deformation.

References

M.J. Kamerling and B.P. Luyendyk, Tectonic rotations of the Santa Monica Mountains region western Transverse Ranges, California, suggested by paleomagnetic vectors, *Geol.Soc. Amer. Bull.*, v. 90, 331-337, 1979.

B.P. Luyendyk, M.J Kamerling, R.R Terres, and J.S Hornafius, Simple shear of southern California during Neogene time suggested by paleomagnetic declinations, *J. Geophys. Res.*, v. 90,12454-12466, 1985.

B.P. Luyendyk, A model for Neogene crustal rotations, transtension, and transpression in southern California, *Bull. Geol. Soc. Amer.*, v. 103, 1528-1526, 1991

R. Butler, Paleomagnetism: magnetic domains to geologic terranes, 1992

R. Sharp, A Field Guide to Southern California, 1994

U.S. Geological Survey, 1992, US GeoData, [brochure]: [Reston, Virginia], U.S. Geological Survey, 2 p. [fold out, oversized]

U.S. Geological Survey, 1992, US GeoData data users guides and associated documentation, order form: [Reston, Virginia], U.S. Geological Survey, 2 p.

U.S. Geological Survey, 1993, Digital elevation models -- data users guide 5: [Reston, Virginia], U.S. Geological Survey, 48 p.

U.S. Geological Survey, 1993, US GeoData digital elevation model, factsheet: [Reston, Virginia], U.S. Geological Survey, 2 p.

U.S. Geological Survey, 1994, Cartographic technical instructions, price list: [Reston, Virginia], U.S. Geological Survey, 2 p.

U.S. Geological Survey, 1994, US GeoData available through the Internet, factsheet: [Reston, Virginia], U.S. Geological Survey, 2 p.