Digital Database Development and Seismic Characterization and Calibration for the Middle East and North Africa

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Extension Report (Supplemental Agreement)
Contract F19628-95-C-0092, P00006

**DIGITAL DATABASE DEVELOPMENT AND SEISMIC
CHARACTERIZATION AND CALIBRATION FOR THE
MIDDLE EAST AND NORTH AFRICA**

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PART I: DIGITAL DATABASES FOR USE IN REGIONAL DISCRIMINATION OF EARTHQUAKES AND MINE-RELATED EXPLOSIONS IN NORTH AFRICA: A JOINT EFFORT WITH THE LLNL

Ground truth information was provided to the Lawrence Livermore National Laboratory for experimental discrimination of mine-related explosions from earthquakes. Remotely sensed data, knowledge of regional geology and tectonics, and other data sets were provided for two distinct projects at LLNL: (1) Detection of recent strip-mining activity using satellite remote sensing by Dr. William Pickles, and (2) Discrimination of mine-related explosions from earthquakes using regional waveform data by Dr. David Harris and Dr. William Walter. The primary contact person at Cornell for this activity was Francisco Gomez, a graduate student whose studies focus on the regional geology and tectonics of Morocco. Two visits were made to LLNL by Francisco Gomez during Winter 1996 and Winter 1997, as well as one visit to Cornell by Dave Harris during the Summer of 1997.

As part of this work, several data products were produced for use of the researchers at LLNL. All of these have already been delivered to LLNL. A summary of these data is given in Table 1.

1. Monitoring mining activity using remote sensing

One of the largest mining operations in Morocco is the phosphate mining near Khouribga and Oued Zem (Figure 1). At these locations, phosphate is mined from extensive sedimentary layers through strip-mining. As a result, mines and piles of tailings are clearly visible in satellite imagery and aerial photographs. Documentation of each mine blast is kept at the ministry, and this is then available to researchers at Cornell. Digital Landsat Thematic Mapper (TM) imagery (ca. 1984) of the region was provided to LLNL for Dr. Pickles' research, along with stereo aerial photographs acquired from the Division of Cartography in the Moroccan Ministry of Agriculture. Published topographic and geologic maps were also provided.

Digital Landsat Thematic Mapper (TM) data were also provided to LLNL as needed, along with data processing algorithms for viewing with ERMapper digital image processing software. Data were provided for several regions of northern Morocco and one area of southern Tunisia. TM data have a spatial resolution of 28.5 meters and provide spectral resolution in the visible, near infrared and mid infrared. The semi-arid to arid climate of much of North Africa is ideal for distinguishing lithological and soil variations.

2. Discrimination of explosions from earthquakes

Other efforts were made to identify mines based on seismic cluster analysis, and once again, we provided additional information to LLNL researchers. These areas were in the region of Gafsa, Tunisia (Figure 2), and the Prerif and Khouribga/Oued Zem areas of Morocco (Figure 1). Landsat TM imagery (ca. 1986 and 1984, respectively) was

Figure 1. Map showing the regions of interest for seismic activity and mine correlation study. KOZ= Khouribga/Oued Zem mining areas; PR= Pre-Rif, MDT= Broadband seismic station

Figure 2. Map showing the location of the area of study in Tunisia.

provided, along with digital image processing algorithms developed at Cornell for use with ERmapper image processing software

One of the key products was a digital database of mines in Morocco. This was produced from information provided by the Moroccan Ministry of Energy and Mines listing all of the mines for metallic and non-metallic resources in the country. This database also includes information about the minerals being mined, the type of deposit, morphology, age, rock type, and mineralogical associations. All of this information was entered into GEOID system for use with other data sets. Locations of each mine are given to the nearest minute. The mines are described in more detail in *Panorama de L'Industrie Minière (Overview of the Mineral Industry)* published by the ministry in 1990. The database does not contain information about periods of activity of the mines, but it is presumed that most in the list were active at the time of publication. This database is also included on the tape with the rest of the database package.

Another product was a digital image file of the *Carte Minière et Energetique du Maroc (Mineral and Energy Map of Morocco)*, also published by the ministry in 1982. Although this information is dated, it is the only published map available and provides information about mine production. The GIS database is more up-to-date than this map.

Identifying phosphate strip mines corresponding with suspected explosions was successful with the satellite imagery due to the surface effects and the distinct spectral signature of phosphate mine tailings. The suspected events in the Pre-Rif region of Morocco, however, were not successfully correlated with mines or mine-like features in the satellite imagery. (It should be noted that the imagery is approximately 5 years older than the data used in the cluster analysis.) These regions involve mining that may employ different techniques.

This effort is ongoing, and we will continue to provide assistance as needed. Dr. Harris and Dr. Walter plan to process more data in Morocco that overlaps with the operation of the Moroccan regional seismic network. This should provide additional constraints on event locations.

Table 1. Table showing data provided to LLNL under this Supplemental Agreement of the contract

Data Product	Date	Source	Format	Notes
Moroccan Mine Database	1990	compiled from data provided by Ministry of Energy & Mines	ARC/INFO, ASCII	
Mineral & Energy Map of Morocco	1982	Ministry of Energy & Mines	scanned from 1 2,000,000 map, in TIFF & BIL formats (w/ Ermapper header files)	
Topographic maps of Khouribga- Oued Zem region	1950s	Division of Cartography, Ministry of Agriculture	1 100,000; paper, scanned at LLNL	
Geologic Map of Khouribga- Oued-Zem	1970s	Ministry of Energy & Mines	1.100,000; paper, scanned at LLNL	
Landsat Thematic Mapper (TM) image data	1984 (Morocco) 1986 (Tunisia)	EROS Data Center (USGS)	BIL files with Ermapper header files	
Aerial photographs of Khouribga-Oued Zem	1990	Division of Cartography, Ministry of Agriculture	1 40,000, paper	

PART II. MIDDLE EAST AND NORTH AFRICA LOCAL COUNTRY SEISMIC BULLETINS

We have organized all of the available earthquake locations, station locations, and phase data from local bulletins from the Middle East and North Africa region. In all cases, except for one, the formats are the same: fixed column, Fortran style ascii formats containing all of the data that we were able to extract from these files. Unfortunately, due to differences in the methods of location from country to country, we left out some of the parameters which are unique to that country's particular network and are not in our estimation vital information. We have, however, provided the original data that we have started from, so users can go back to the original data to extract these attributes. These data are provided in the attached digital tape. It is also important to note that we have finished putting 31 years of ISC phase, event, and station data (totalling some 25 million phase readings) into ARC/INFO format as well as having incorporated it into our GIS menu system. This database will provide an even more comprehensive database than the one we are providing here. We have also included phase readings from the Lebanese station BHL. This data file has not been reformatted since Lebanon does not currently produce earthquake location bulletins and hence we were not able to associate the phase picks with earthquakes using a local catalog.

1. Earthquake Catalogs

The formats for the local/national earthquake catalogs for the Middle East are generally fairly similar. Unfortunately most countries provide very little information concerning the error analysis. The format we have used for these ascii flat files is uniform except for Turkey. We have a catalog which has been compiled from a variety of networks in Turkey since 1985. This is a very large catalog since it includes seismicity in western Turkey.

Phase Data

We have phase data for three countries: Syria, Morocco, and Saudi Arabia. The data files with the format below have been created by extracting phase data only when the event coordinates were given. In the original phase files there are a large number of phase readings for unspecified and unassociated teleseismic and regional events. We have also included phase data from Lebanon; however, the phase picks have not been associated with corresponding seismic events since Lebanon does not produce a national catalog.

Station Data

Along with each of the phase data files we have given corresponding station files. All stations referenced in the phase data files are present in these files. All of the station names are unique, that is, if a station changed location we have changed the name of that station name in the phase and station data files.

Hardcopy Catalogs

Cornell also has a large number of hardcopies of local earthquake catalogs and phase readings. Within this database we have phase reading and earthquake location data for

Israel from the period 1982 to 1991 We also have earthquake locations and phase data from Jordan for the years 1983 through 1991 in hardcopy form For Yemen we also have phase readings and local earthquake locations for the year 1996 We have phase readings as well as earthquake locations from the Kandilli Observatory seismic network in Turkey Upon request we would be happy to provide some hardcopies of some of these bulletins

All digital files of local country bulletins from the Middle East and North Africa region are included in the enclosed CD ROM disk.

PART III: METADATA

It is important that data be accompanied by written documentation to enable accurate assessment of their reliability. Metadata, or "data about data", describe the content, quality, condition, source, history, and other characteristics of a dataset. Without metadata, this information is known only to those who acquired or modified the data and the data lose value as the information is lost. With metadata, prospective users can determine what data exist, the fitness of these data for their applications, and the conditions for accessing these data.

To provide consistency for users with datasets from other sources, the Federal Geographic Data Committee (FGDC) Content Standard for Digital Geospatial Metadata was applied. Metadata standards facilitate data sharing through time and space. The standard specifies the information content of metadata for a set of digital geospatial data; its purpose is to provide a common set of terminology and definitions for documentation related to these metadata. The standard establishes the names of data elements and groups of data elements, the definitions of these data elements and groups, and information about the values that are to be provided for the data elements.

The FGDC data elements are as follows:

Identification Information - basic information about the data set. Examples include the title, the geographic area covered, currentness, and rules for acquiring or using the data.

Data Quality Information - an assessment of the quality of the data set. Examples include the positional and attribute accuracy, completeness, consistency, the sources of information, and methods used to produce the data.

Spatial Data Organization Information - the mechanism used to represent spatial information in the data set. Examples include the method used to represent spatial positions directly (such as raster or vector) and the number of spatial objects in the data set.

Spatial Reference Information - description of the reference frame for, and means of encoding, coordinates in the data set. Examples include the name of and parameters for map projections or grid coordinate systems, horizontal and vertical datums, and the coordinate system resolution.

Entity and Attribute Information - information about the content of the data set, including the entities types and their attributes and the domains from which attribute values may be assigned. Examples include the names and definitions of features, attributes, and attribute values.

Distribution Information - information about obtaining the data set. Examples include a contact for the distributor, available formats, information about how to obtain data sets online or on physical media (such as cartridge tape or CD-ROM), and fees for the data.

Metadata Reference Information - information on the currentness of the metadata information and the responsible party. Examples include currentness and information about the organization that provided the metadata.

Metadata for Cornell data sets take about 350 pages when printed. The complete set of printouts are available in our Final Report. However, with this extension report we provide a CD ROM with all Metadata in HTML format that can be viewed in any web browser. Please see the enclosed CD ROM for individual Metadata for our data sets.

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