Satellite Based Seismic Technology

Dr. V.K. Srivastava, R. Ghosh*, B.B Chhualsingh
Department of Applied Geophysics, Indian School of mines, Dhanbad.
E- mail: ismkvinay@hotmail.com, ghosh.ramesh@rediffmail.com, bidya.singh@rediffmail.com

Summary

Depiction of depth through different experiments for placement of charge is a prerequisite for seismic data acquisition. One of the primary ways to find hydrocarbon deposits on land is seismic surveying, which can involve a crew of hundreds of people, a fleet of large trucks, seismic energy sources and thousands of geophones to measure sound waves as they travel through Earth. However it's a relatively expensive endeavor and one that's not guaranteed to find hydrocarbon. In such cases, satellite imagery can tell us where to stop wasting the time and money running expensive surveys that won't work and it can also provide different types of information that might be helpful in oil and gas exploration. In this present work an integrated approach of remote sensing and GIS technologies were used to generate a seismic quality map(Laake and Insley 2004), which reduce the risk of acquiring poor-quality seismic data. Near-surface lithological characterization using Earth Observation (EO) data may assist seismic data processing in building a more accurate earth surface model. The workflow to generate a seismic quality map and the integration and analysis stages involved generating multiple image layers, for textural analysis and interpretation of surface faults and fractures, and a derived principal component analysis of multi-temporal remote sensing data for analysis of surface moisture characteristics of study area around Dun valley in the foothills of Himalaya.

Introduction

Seismic survey design seeks an acquisition geometry that is optimized for geophysical goal, meets safety/environmental requirements, and is economically viable. The key parameters for defining the optimum survey geometry are usually derived from illumination studies that determine ideal source and receiver locations. High-resolution visible light images provide information about infrastructure, vegetation and land use that helps determine accessibility for vehicle and people. The seismic source signal quality determined by ground coupling, i.e. it depends on the elastic properties, gradient and composition of the surface. For example, hard rocks and large boulders indicate probable vibrator coupling problems and consequently result in very poor signal transmitted into ground. In very soft areas, it will be difficult to transmit high-frequency energy into ground. Drainage patterns such as wadis also indicate zones of difficult coupling for source and receivers.

An integrated approach of remote sensing and GIS technologies provides better opportunities not only for geological mapping, but also for geological interpretation and implementation of exploration programs in difficult terrains with greater accuracy and in a cost-effective manner (Everett et al. 2002; Harris and Cooper 2002; Laake and Insley 2004).).

As various scientists have published their work, on Similar line we have also tried here to use these techniques in a mountainous terrain in and around Dehradun valley of Himalayan region, India in order to suggest seismic quality parameters in the region.

Data used The following data sets from different sources were used in the present study:

1. IRS-1C LISS-III (band 3 and 4)
2. Existing geological maps and topographical maps (1:250,000 scale).
3. Elevation data of the area from Google Earth data.

Methodology

Figures 1 depicts the various steps undertaken for image processing.

First the univariate data analysis is done on the Georeferenced data of IRS LISS III data in order to understand the magnitude (value), variability and distribution is crucial for recognizing the adequately of analytical procedures applied to these data. The images of LISS III band 3 and band 4 data are shown in fig .. the histograms are generated by using the Erdas Software shown in fig. then these data are imported to MATLAB software for further analysis. Then different enhancement techniques

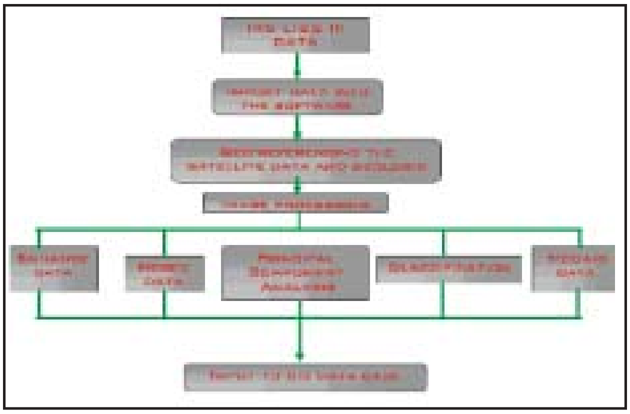

Fig.1. Production chain for image processing component of the seismic quality.

are applied to the raw data. To take advantage of the spatial resolution and spectral resolution of the IRS 1-D PAN and LISS III images, respectively, both the images Satellite based seismic technology were "resolution merged" together to obtain a multi-spectral image having higher spatial resolution. In order to get the visual understand the data principal component analysis is done.Classification is done for the identification of the texture. In this case, the objective is to identify pixels that have similar spatial relationships. Skewness based texture classification estimates the third order statistical moment to correlate spatial variation of objects on the ground. A contour map also has been prepared from the elevation data taken from Google Earth software following a trend surface model.

Case study

Dun valley which is a synclinal basin filled with coarse clastic fan deposit of late Pleistocene and Holocene age known as dun gravel. It is controlled by many tectonic faults and main thrust boundary thrust. Geomorphically, the Dun valley can be divided into two slope regimes by axial drainage of NW flowing Asan and SE flowing Suswa-Song rivers (fig-2) joining the Yamuna and Ganga rivers respectively. The northen slope of the valley is occupied by three main piedmont fans of post-Siwalic Dun gravels, viz. Donga fan, Dun principal fan and Bhogpur fan(fig-). An anomalous ~850m high topography of Nagsidh hill with radial drainage pattern, peculiar in Dun valley, lies in distal part of Dun principal fan(fig-2).

Seismic survey in such geologically complex area has considerable impact on logistics and data quality of surface seismic acquisition. The raw image of the study area are shown in the fig-4 followed by RGB images, histogram and contrast enhancement.

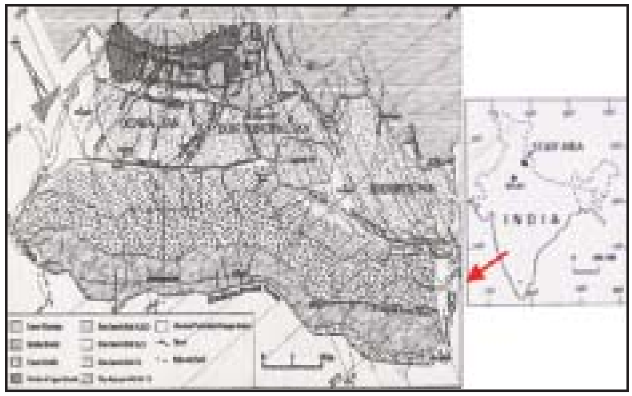

Fig. 2 Geological land cover map showing distribution of Siwalic and post Siwalic Dun gravels in the Garhwal sub-Himalaya, after Thakur, V.C.

Fig.3. Quick-bird image of the study area taken from Google Earth software.

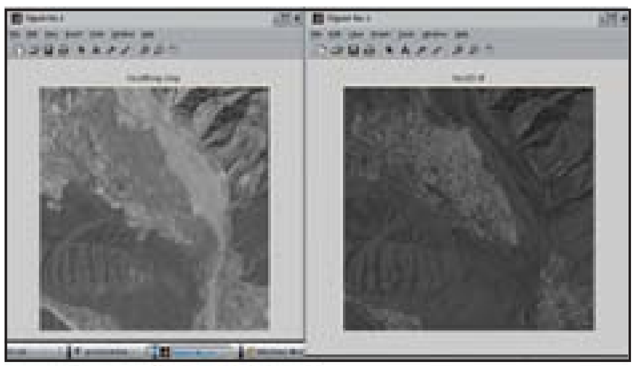

Fig.4 BAND 3 DATA BAND 4 DATA

Then the contrast enhancement (histogram equalization) is applied to achieve more or less equal frequencies among the different pixel values, thus rendering a transformed image for which no particular range of of pixel values is dominant. The outcome has a tendency to appear harsh.

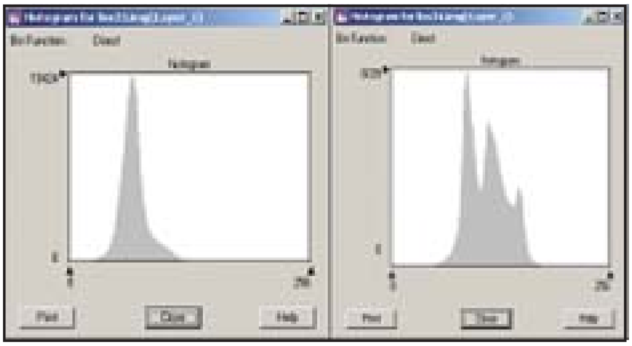

Fig.5 Histogram of LISS-III band 3 and band 4 data.

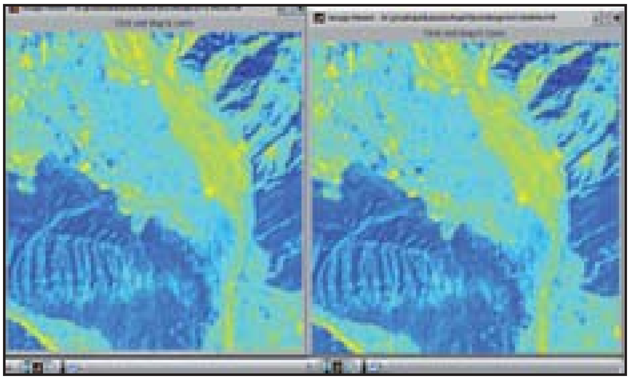

Fig.6 RGB images of LISS-III band 3 and band 4 data

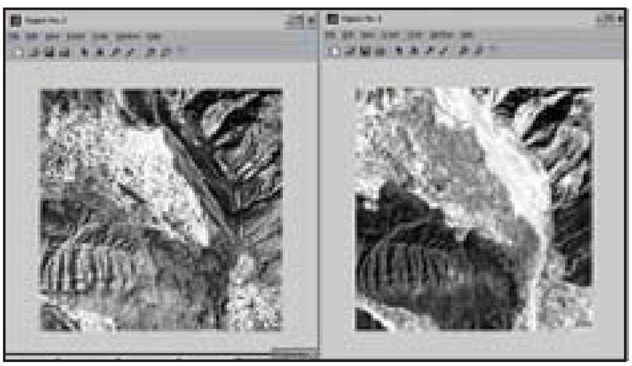

Fig.7 : After histogram equalization.

The high frequency and low frequency components of the image are separated by using edge detection filters viz. Sobel filter and canny filter as shown below.

In the above figure one can clearly view high frequency areas such as Dehradun town(settlement area), Lesser Himalaya, Southern side of the Bhogpur Fan, and radial Drainage pattern of Nagsidh Hill as well as the low frequency areas such as southeast part of Dun principal Fan, area over Nagsidh Hill and Song River.

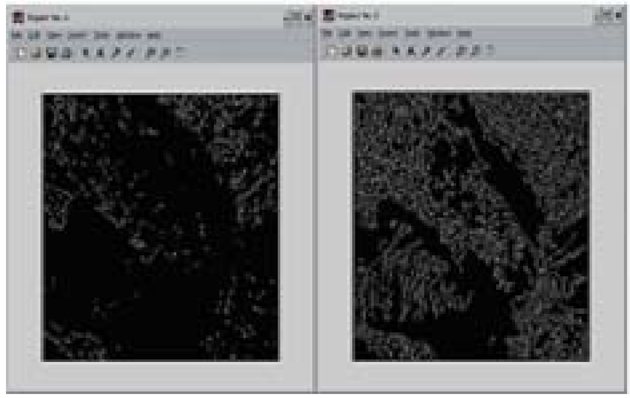

Fig.8 After applying edge enhancing filter.

By combining Bands 4 and 3 of the LISS-III image, a false color composite (FCC) was generated. Spatial enhancement was also done to the LISS-III images. The merged data is shown in figure below.

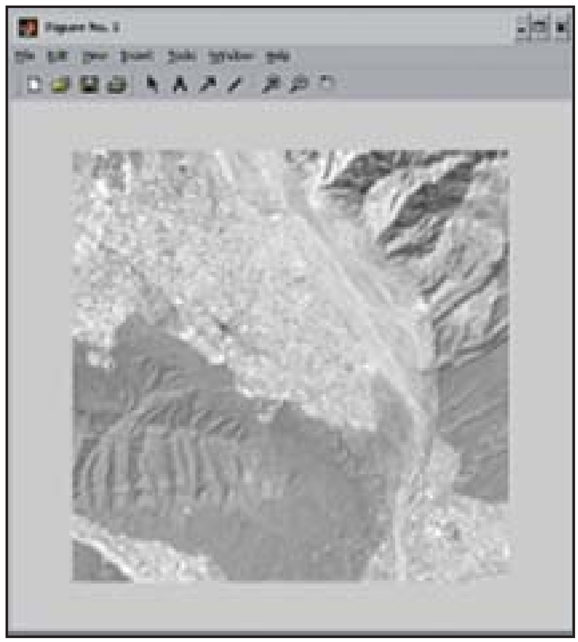

Fig.9: Merged data of band 3 and 4.

One of the approaches to image classification is the identification of texture. Spatial variation of grey tone is called texture which determines the overall smoothness or coarseness of image features. Textural analysis reveals the structural arrangements of the object in the image and provides important discriminating characteristic to the variability patterns of land cover classes in the photo interpretation and digital classification. Skewness based textural classification estimates the third order statistical moment to correlate spatial variation of objects on the ground. Skewness of the DN dispersion with in a moving window of specified size is measured. Here the textural classification of the LISS-III band 4 data has been generated.

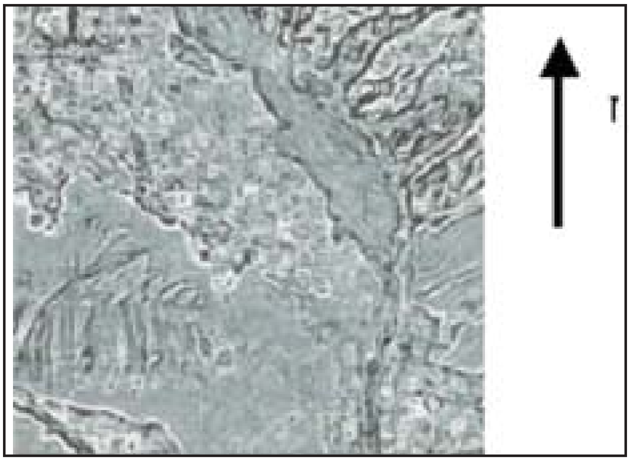

Fig.10 : Textural classified image of a part of Dun valley based on skewness (Window size: 7×7)

The ripples found in Dehtadun town area, southern part of the Nagsidh Hill along the Suswa River and in the southern side of bhogpur fan are the indicative of settlement area. The Dun principal fan along the Song River, northen part of Bhogpur Fan at the foothill of Lesser Himalaya, Nagsidh Hill and southern side of the Suswa Rivrer are classified as one unit of low frequency. The band patterns over the Lesser Himalaya are indicative of repetitive modulation that means crest and though. The separation between comparable spatial variations are depicted the contrasting dark lines. These characteristics are very much similar to the edge enhancing filter. The Song River is identifiable by different Grey tone where as the Suswa river is classified as one textural unit. The radial drainage patterns over Nagasidh Hill are also distinct. A contour map the study area has also been prepared as shown in figure-11 followed by a surface trend map.

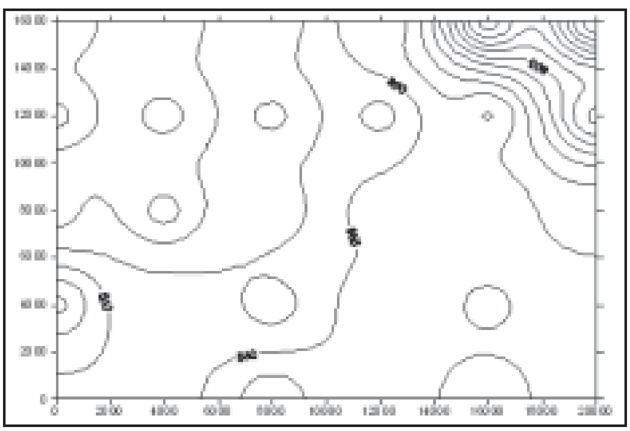

Fig. 11: Contour map of the study area

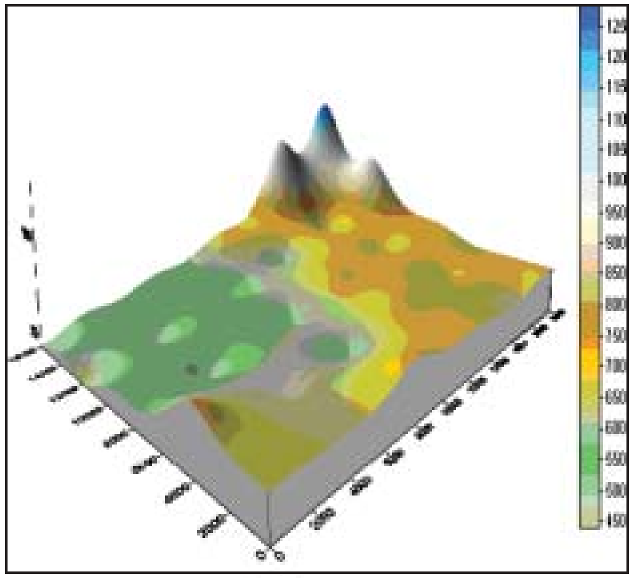

Fig.12 : Surface trend map of Dun valley region.

Conclusions

Satellite imagery data are being used for improvement of survey design and these data provides valuable information for planning survey. The data flow for future work that employs satellite imagery to prepare seismic quality map is shown in fig-13. This involves

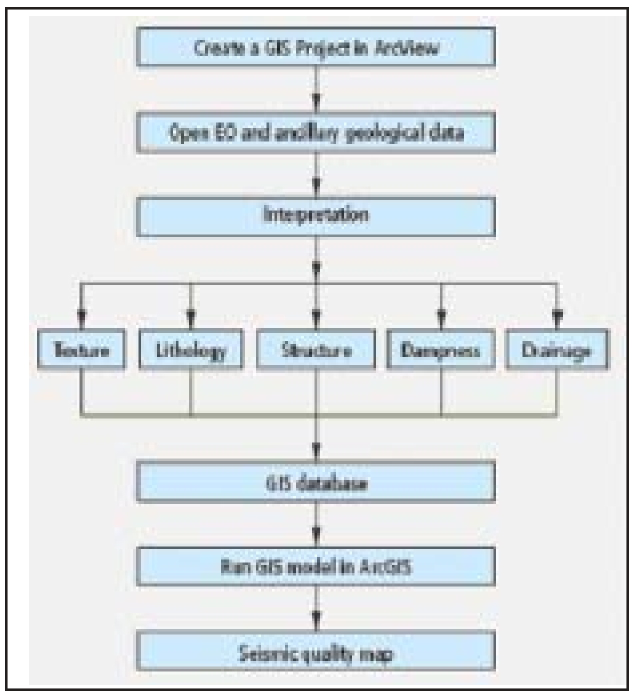

Fig.13. Production chain for image interpretation, integration and analysis within the GIS component, after Laake and Insley.

integration and analysis stages for generating multiple image layers. This will help in textural analysis and interpretation of surface fault and fractures. Attributes like source receiver coupling also related to static correction and may be useful in quality control and data processing.

Acknowledgements

We thank Dr. **Andreas Laake,** WesternGeco, Gatwick, UK for providing us some useful literature and suggestion during the preparation of this work.

References

Carr, j. R.,1996,Spectral and textural classification of single and multiple band digital images, Computer and Geosciences Vol.22,No.8,pp849-865.

Everett J. R., Jengo C. and Staskowski R. J., 2002. Remote sensing and GIS enable future exploration success. World Oil, vol.223/11, 59-65.

Laake A. and insley M., 2004..Application of satellite imagery to seismic survey design. The Leading Edge, October.

Laake A. and insley M., 2004. Using satellite imagery aids seismic surveys in planning, acquisition and processing. World Oil, vol.225/09, 59-65.

Thakur, V. C., Pandey, A.K., Dec 2004, Late Quaternary tectonic evolution of dun in fault bend/ propagated fold system, Garhwal Sub-Himalaya, Current Science, Vol. 87, No. 11.