Using Remote Sensing to Identify Potential Fossil Localities in the State of Montana, USA

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Abstract

Advances of remote sensing in the last decade have had important implications in science and especially in geology. Nevertheless, in the field of paleontology, incorporation of remote sensing is limited. This study tries to establish a model that can help identify new potential fossil localities in the state of Montana with satellite images obtained from Landsat 7 ETM+ sensors (date 2003). These images were processed using ENVI 6.0 software. Unsupervised ISODATA was obtained from image processing and was compared with a geological map of the area to identify matches. Despite similarities with the two, no new fossil localities could be identified given the limitations found with the methodology used in this study. Further improvements are a must to establish new reliable possible fossil localities.

Introduction

Remote sensing techniques have been developed in recent years to help the identification and remote analysis of rocks, minerals and tectonic structures. (Malakhov, D.V 2009). Applications derived from satellite images and remote sensing techniques are not only limited to just observations of the surface of the planet, but a combination of approaches have been developed in order to help scientists obtain key information about historical geological features or to even determine conditions underground by noticing aspects of the surface (Akhir, J.M. 1997).

However, when it comes to the field of paleontology, little studies have been done in order to implement this helpful technique. The main problem when it comes to utilizing remote sensing in paleontology comes from main factors. First, Not all sedimentary rocks recorded on a geological map are exposed or cropping out on the surface. Most if not all of the fossil specimens can be easily recovered from exposed localities (Dunhill, A.M. 2011).

The purpose of this study is to establish a model that can help find potential dig sites for academic uses. As well, compare images processed in ENVI 6.0 software with known dig sites to try and establish a new potential fossil localities.

Materials and Methods

Area of Study

When it comes to locating and identifying new potential dig sites, weather conditions and the exposure of rock material are the number one factor to consider. The selection of the state of Montana as the area of study was in addition supported by its rich paleontological record as well as all the over exposed rock material. Given the large area of study, focusing on a particular area is ideal in order to get the most out of the established methodology.

For the exact area of focus, the Mother's Day Quarry of the Upper Jurassic Morrison Formation was chosen. The Mother's Day Quarry falls within the Salt Wash Member of the Morrison based on regional lithologic correlations. In general, this quarry is characterized by an abundance of sandstone beds and conglomerates, which suggest a significant fluvial influence. In addition, the quarry has seen numerous paleontological discoveries, in particular with juvenile or subadult sauropod material (Myers, T.S. 2007).

Image Acquisition

Landsat 7 ETM+ (Landsat Enhanced Thematic Mapper) is the main sensor used for this study and provides imagery of a spatial resolution of 30 meters. Image sets for Landsat 7 ETM+ were found using USGS EarthExplorer. Given that Landsat 7 ETM+ is no longer in service, the time frame for this study is January 1st to December 31st 2003 with cloud coverage set to less than ten percent. Available datasets were then processed by using ENVI 6.0 software.

Spectral Analysis

For the datasets spectral signatures were defined by using the band combination 7-3-1 for R-G-B (red, green and blue respectively) using ENVI 6.0 software. These band combinations were chosen given that it provides the greatest image contrast. Afterwards a subset of the original image was generated to emphasize the area of study near Mother's Day quarry. This subset was done for both the true color image (3-2-1 band combination) and for a false color image (7-3-1 band combination). For these subsets an unsupervised ISODATA classification was then selected with 5 classes over three iterations as conditions with the rest of the parameters in their default settings.

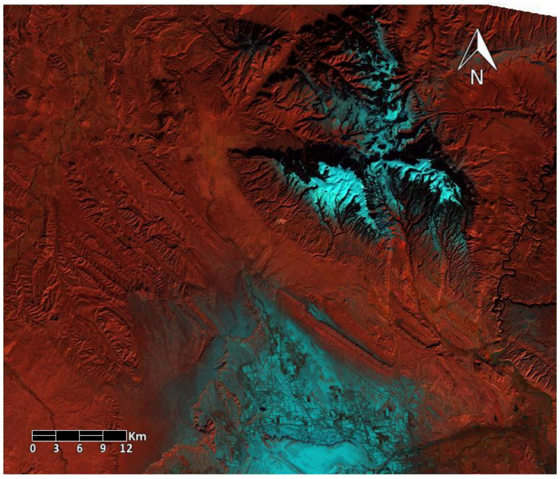

Fig. 2. Landsat ETM+ Montana, USA. False color.

Results

Data comparison done between true color and false color image (Fig. 1 & 2.) with ISODATA classification (Fig. 3) proved that the classified regions were in agreement with what can be visually confirmed. In addition, when compared with the geological map of the area, a connection can be made between geological observations.

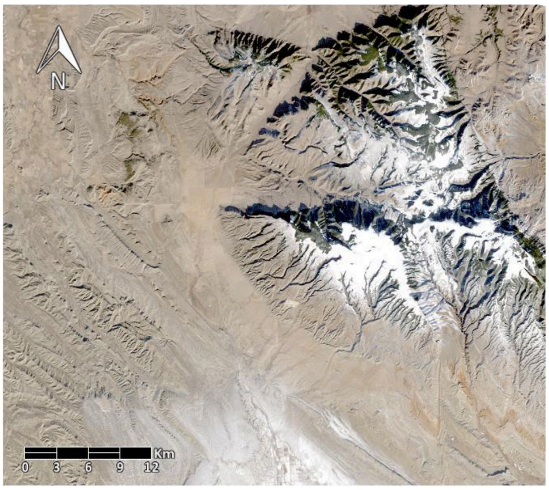

Fig. 1. Landsat ETM+ Montana, USA. True color image (Logarithmic stretch)

The unsupervised ISODATA classification generated five classes with one unclassified (Fig. 3). When compared with the geological map of the area matches can be made primarily by the type of rock exposed in the area. However, despite the ISODATA generating areas similar to those found on the geological map, inconsistencies are notable. Some areas overlap and are over represented when compared to the geological map. This margin of error can create inconsistencies when trying to find ideal fossil localities. It is for this reason that identifying new potential fossil localities in this study is unreliable.

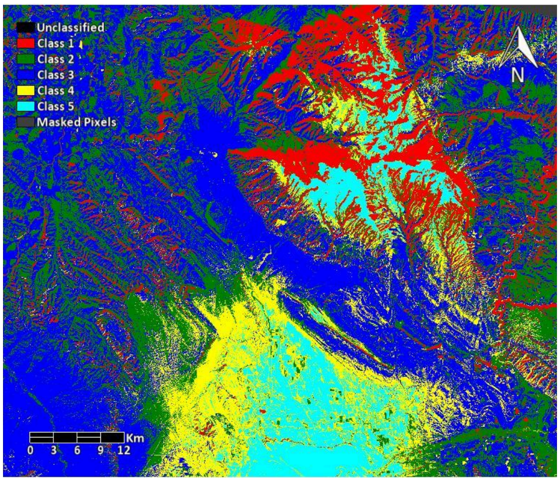

Fig. 3. ISODATA unsupervised classification

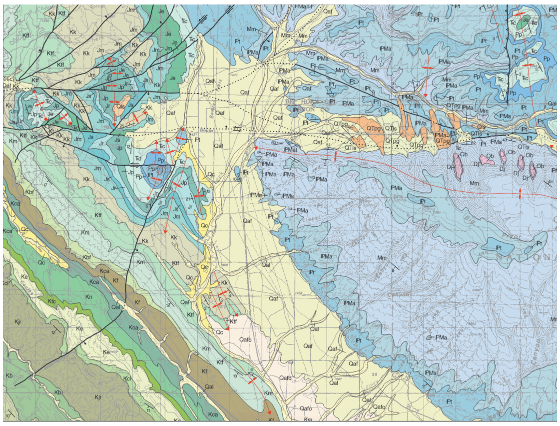

Fig. 4. Montana geological map.

Conclusion

Previous studies have shown that using Remote Sensing techniques to identify new potential fossil localities have indeed shown promise (Malakhov, D.V. 2009). However, the results of this study show that further studies are needed to improve the reliability of these new innovative methods of finding fossil localities.

Limitations were encountered, mainly with the accuracy of the spectral analysis and its ability to distinguish related spectral sets.The reason for this can be due to the spectral characteristics of these units are similar (in Landsat images) to those of the Upper Jurassic strata in the area of interest. Given this limitation, identifying new fossil localities are difficult with images alone.

Needless to say, with further studies and modifications to the previous methodology, classification and interpretation of satellite images could help paleontologists in identifying new fossil localities in the future. Switching to a sensor that has a higher resolution can help distinguish overlapping classes. Furthermore, Spectral Angle Mapper (SAM) supervised classification can be applied in order to compare spectral results more precisely with geological data of the area of study.

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