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Paper G 6

CAPABILITY OF ERTS-1 IMAGERY TO INVESTIGATE GEOLOGICAL AND STRUCTURAL FEATURES IN A SEDIMENTARY BASIN (BASSIN PARISIEN - FRANCE)

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ABSTRACT

A preliminary study of the MSS imagery is in progress on a sedimentary basin whose structure is regular. Crops and natural vegetation are distributed all over the site located under temperate climate. Ground data available concern plant species geology and tectonic and are correlated with results from ERTS 1 imagery.

This comparison shows a good correlation.

The main geological units are detected or enhanced by way of agricultural land use and/or natural vegetation. Alluvial deposits are outlined by vegetation grass land and poplar trees.

Some spatial relationship of geostructures, suspected until now, are identified or extended in associating results from different spectral bands.

I/ INTRODUCTION

The MSS images which form the subject matter of this communication (1) are situated outside the test-site we proposed for NASA, i.e. the Massif Central. However they do partially resolve a problem which we brought up in our proposals, that of the possible prolongation of the important Sillon Houiller fault towards the North-East outside the Massif Central and particularly the possible relation to the Metz fault.

The work was realised by visual study of Bulk black and white 9"1/2 positive paper prints with an enlargement system. The interpretation made on overlay was renewed for each spectral band and then compared with existing cartographic documents.

II/ GEOLOGICAL AND PHYSICAL BACKGROUND

The MSS images examined cover an eastern sector of the Parisian Basin between the towns of Laon in the NW, Briey in the NE, Langres in the SE and Sens in the SW. The town of Vitry-le-François is approximately central halfway between Paris and Nancy.

The region in question has a very regular relief of shelving plateaux bounded one from the other by erosion "cuestas". The highest section (average altitude 400-500 m) is in the SE angle (Langres Plateau) ; the lowest point (about 50 m) in the NW (the Aisne valley). The general orientation of surface drainage is in direct relationship with the hypsometry : all the important rivers : Meuse, Marne, Aube, Seine, etc.. have their sources in the SE and flow towards the N, NW or W.

The formations represented are of sedimentary origin. The oldest, being of the Liassic Age, outcrops in the SE ; the most recent except for Quaternary formations, are of the Oligocene and are found in the western sector. From the SE or NE towards the W the succession of outcropping formations is regular at the scale considered and shows concentric strata of the Jurassic, Cretacious, and Paleogene.

This arrangement has no relation to a progressive recession of the Triassic and Oligocene marine water towards the center of the basin and on the contrary is essentially due to the Tertiary and Quaternary erosion in relation with Pyreneo-Alpine tectonics and climatic variations. The parisian basin's great natural unity at present is the result of a very complex geological history beginning at the Paleozoic and continuing still.

The sector under consideration shows a general dip of the eastern peripheral beds towards the West, this being in relation with the slightly subsident synclinal basin, practically centred on Paris, which was laid down during the Cretaceous Age and received its individual character essentially during the Paleogene. This monoclinal structure is complicated in its details by folds and faults among which may be distinguished those of Armoricain (NW-SE) and Variscian (SW-NE) orientation on the one hand and radiating and concentric faults on the other hand, linked to the Pyreneo-Alpine orogenesis. The former are generally interpreted as superficial reappearance of the great Hercynian faults affecting the Paleozoic foundation of the basin. The latter are put in relation with the architectural model of the Cretaceo-Tertiary Parisian Basin.

III/ CONTRIBUTION OF THE STUDY OF MSS IMAGES

3.1. Land Use

In a region such as the Parisian Basin land use is the most accessible parameter at the orbital scale. Consequently it is necessary to analyse rapidly the vegetation signal in the different spectral

bands before evaluating the contribution of MSS images to geology.

Band 4 - important scattering effects and the image is hazy
Band 5 - gives an excellent view of land use repartition.

The distinctions below are made possible by the strong absorption of the vegetation in this spectral band :

gray scale 14:forests

gray scale step 12:association of cultivation and grassland over humid grounds, of grassland and poplar trees along the water courses, Champagne vinyards.

gray scale step 10:cereal cultivation and pine woods on Chalky soils.

Band 6 - the increase of reflectance leads to a leveling of the cereal cultivation and grasslands signal, making possible a good discrimination of the forests.

Band 7 - the principal difference with Band 6 is the disappearance of the forests.

3.2. Geological Mapping

The region covered by the MSS images has the benefit of complete geological mapping at the scale of 1/80 000, 1/320 000 and 1 1 000 000 revised several times over the last century. The geological map at 1/50 000, is in course of preparation, the published sheets concerning essentially the western third and the angles NW and SW.

Talking this into account the MSS images do not add anything new of importance concerning outcropping formations in the sector under consideration. However the comparison of the images and the existing geological maps, particularly the one at the scale of a millonth, produces important information of two winds :

. First, a good correspondance is seen between the large units distinguished at first sight on the images (in particular band 5) and the concentric strata of the Jurassic, Lower Cretaceous, Upper Cretaceous and Paleogene on the map. The extension of the modern alluvia of the valleys is also easily seen on the images. Obviously, in view of the result of this comparison, such images contribute a great deal to geological mapping at a large scale of regions whose geology is not so well known as that of the Parisian Basin. In particular these images seems to be suitable for resolving problems faced by the geologist when preparing large research expeditions (the preliminary photo interpretation and the choice of itineraies can only be made easier).

. Secondly, the comparison of MSS images with the geological map at a millionth shows, in some sectors, notable differences linked to the very conception of the geological map considered which introduces exclusively stratigraphic distinctions, ignores the representation of covering deposits and does not express lithological variations.

Thus in the sector between Troyes and Sens the map only shows the Upper Cretaceous (chalk) formations and parts of the lower Eocene (sands, s.. ngles) purposely omitting the flinty clay covering, the result of surface alteration of chalky grounds during the Tertiary. These covering grounds which do not exist further North, support a forest vegetation similar to that of the Tertiary deposits, at the beginning of the apparent continuity shown by the MSS images.

In another respect the very dark and palpably median formation on the MSS images (particulary band 5) corresponds perceptibly to the South of Vitry-le-François to the outcropping of the sandy and argillaceous grounds of the Lower Cretaceous to the exclusion of the Cenomanian chalk. To the North of Vitry-le-François this encloses Cenomanian grounds represented by sands and marls which support a vegetation comparable with that of the Lower Cretaceous grounds. In these particular cases there is only an apparent contradiction between the image which expresses lithological differences and the geological map with the conventional stratigraphic limitations.

The comparison of MSS images and the hydrogeological map of the Parisian Basin at 1/500 000 which shows the great lithological formations, removes all ambiguity (fig.1).

3.3. Analysis of geostructures

Amongst the many faults revealed by the study of the MSS images we shall consider only three (successively those of Metz, Juranzé and the double fault of the Marne).

3.3.1. The Metz Fault

Revealed by G. GUERRIER and P. PRUVOST the Metz fault represents the southern boundary of the "bassin houiller lorrain". A south-west extension of this fault has been discovered by drilling up to Saint-Mihiel Commercy (on the river Meuse). These drills hole carboniferous show the existance of an important Hercynian Tectonic rift valley with a carboniferous filling of 4 000 m (2 000 m at Metz).

From the Meuse - the orbital images not covering the zone further to the East - we have noticed a conspicuous alignment unknown until now, passing by Bar-le-Duc, Vitry-le-François, merging at its western end with the linear course of the Seine revealed by spectral band 7. It ends in the West at Montereau against the group of North-South faults extending those of Limagne and the sillon houiller.

The aero-magnetic map of France, 1/1 000 000 scale, confirms the existence of such a fault but slightly more to the South than that traced by the MSS images (and one may deduce that this fault is not vertical). According to these same geophysical methods the North-South faults cut the principal fracture.

The gravimetric data (scale at 1/1 000 000) express more differences but J. GOGUEL emphasizes the Vitry-le-François anomaly and

formulates hypotheses which, up to Arcis-sur-Aube, agree with our interpretation.

Finally to the West of Arcis-sur-Aube he situates a possible continuation of the fault, but more to the North, near to Provins.

The isopach curves of the Permian Age, established by J. LIENHARDT, show that the fracture we are considering could form the southern boundary of the Courgiveau - Trois Fontaine - Saint-Michel (50 m of the Permian) high, whose NE-SW direction corresponds with the direction of the Metz fault.

Finally, Claude MEGNIEN points out NE-SW undulations of the subsurface at the base of the Tertiary, to the South of the Marne (Villier St Georges - Provins), which correspond to structures situated immediately to the North of the Seine. The fracture seen on the MSS images is parallel to these structures and could mark out a flexure.

We come to the conclusion, following J. LIENHARDT that the Permian comes to fill in the paleo-relief sculpted by the Hercynian Tectonic and that this Tectonic imposes its style over the whole basin : the epicretaceous fractures would be traced on these movements. We may think that the fault emphasired by the MSS images reflects, at the level of the Cretaceous, a deep structure of Ante Permian and Variscian direction. The knowledge of these faults is important in trying to understand the Hercynian paleogeography which could guide research for new coal-bearing structures ; and all new discoveries in the sphere of tectonics could start up again research for petroleum which up to now has only happened on the Dogger. Thus MSS images may be considered as an extra tool for the geologist and may certainly have economic influence.

In conlusion the continuity of the fault interpreted on the MSS images is corroborated by complementary and fragmentary information from numerous methods of geological investigation. Without entirely proving the relation between this fault and the sillon houiller faults and those of Limagne - at least in its northern extensions - it shows clearly enough that the phenomena presented by J. GROLIER and J. LETOURNEUR may very probably exist.

3.3.2. The Jurenzé fault

The Jurenzé fault revealed by gravimetric and aeromagnetic surveys is a south-eastern continuationof the large Pays de Bray fracture. This fracture is seen on MSS images from Brienne-le-Chateau towards the East. The satellite image is particularly interesting in that by means of complementary spectral bands - phenomenum already noted for the Metz fault - we observe that this fault divides beyard Brienne into two branches of equal importance. The first, in the North and already known, follows an East-West course and represents an extension of the Vittel fault. The second, further South, follows a North West-South East direction, passes through Bar-sur-Aube and was

unknown until now. The convergence of these two faults constitutes a tectonic trap which had been suspected during research for petroleum but which was not proved because localisation of the phenomenum was inexact. This therefore constitutes an interesting contribution of the MSS images.

The non-visibility of the Juranzé fault's extension towards Bray in the NW is explained in that we know, thanks to F. HERITIER and J. VILLEMIN, that the Upper Cretaceous is not faulted here , a compensation of thickness being produced at the level of the Albian. Consequently it is difficult for us to study on MSS images the interactions of the two most important faults of the Parisian Basin, the Metz fault's extension, and that of Bray-Jurenzé (J. GOGUEL notes that this interaction could be situated at different depths and could cross each other).

3.3.3. The double fault of the Marne

This was first described by R. ABRARD and G. CORROY who ascribed to it a total length of 50 km. Gravimetric interpretations confirm its importance. The MSS images make it possible not only to find again the trace already known but also to suggest a prolongation towards the SE which would bring its length to 110 km. It would seem, according to the interpretation of the MSS images that this fault system cuts again the Metz fault.

3.3.4. General tectonics

In general, without going into detail concerning the many other fractures discerned on MSS images which may be compared with faults on the geological map at the same scale, the following may be concluded :

- it is band 5 which gives the most information concerning the fracturation. It shows features emphasized by boundaries of cultivation associations, or natural vegetation, as well as by poplar trees which show the trace of water courses of an average importance,

- bands 6 and 7 show the fractures emphasized by the forest boundaries and by the linear trace of water courses where the alluvial zones occupied by poplar trees are very developed. In the case of the Metz fault's extension towards the South West bands 6 and 7 are most important in that in this way the course of the Seine can be observed, blotting out the poplar trees. As for the scale this makes it possible to disregard the numerous meanders which characterize the Seine and to retain just the straightness of its course, particularly conspicuous at the scale under consideration.

- bands 5, 6 and 7 are therefore complementary.

IV/ CONCLUSIONS

The example described shows that within sedimentary basin known for its regular disposition in a region where vegetal cultiva-

tion takes up almost all the surface, MSS images at a small scale can give very interesting information concerning :

- the lithology which is cultivated areas is represented by the associations of different cultures and a specific division in land use and in regions of natural vegetation by the associations of forests and grasslands closely linked to the lithology,

- lineaments for which the contribution of the scale is of major importance. Indeed, in this way, elements which appear discontinuous at conventional scales of observation can be integrated into one same alignment.

Certainly one of the most remarkable lessons we may draw from ERTS 1 images is that deep structural elements under a thick sedimentary cover can be translated on the surface by indirect criteria.

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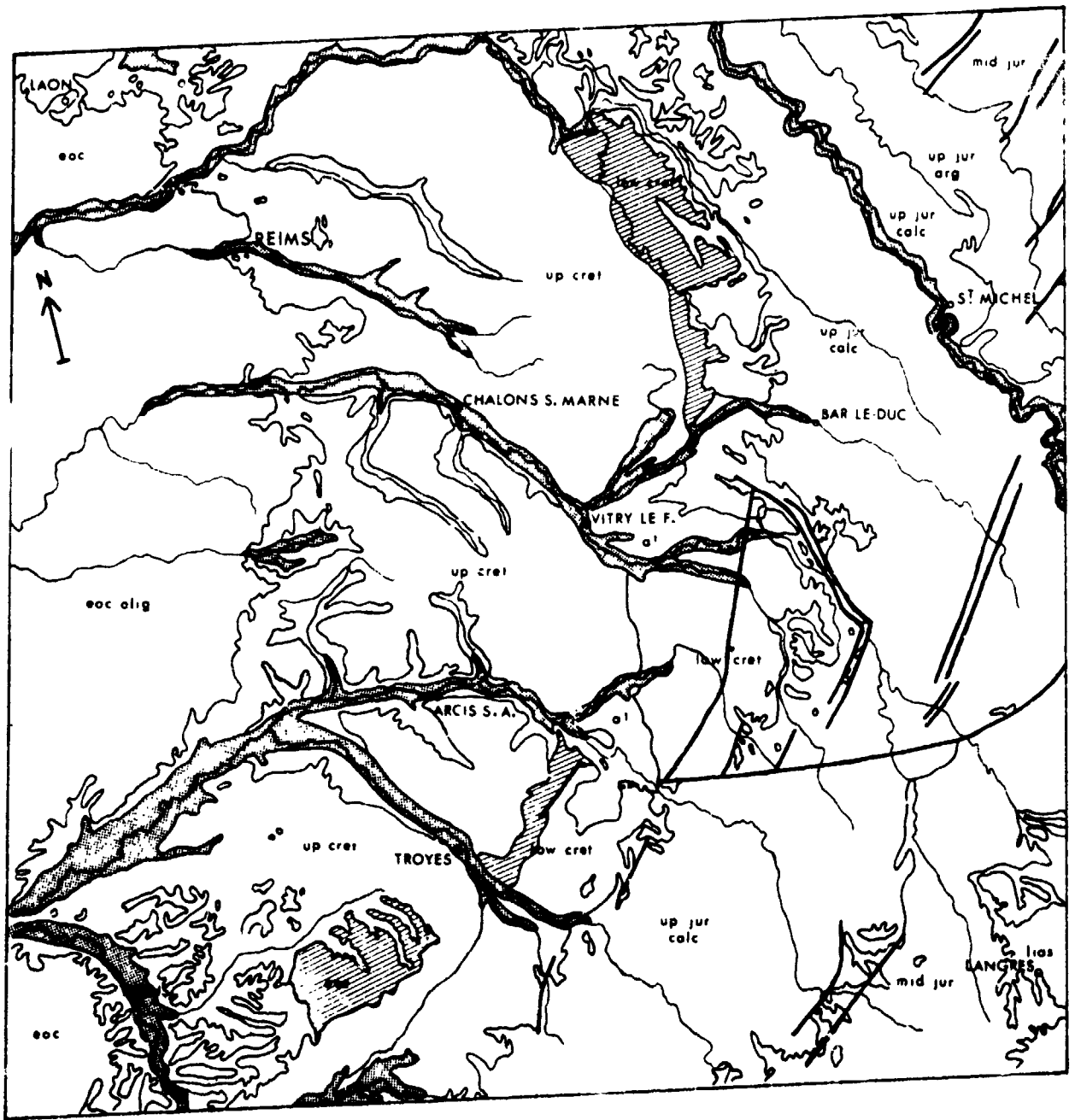

Geological map Scale 1/1.000.000
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Figure 1

Figure 2

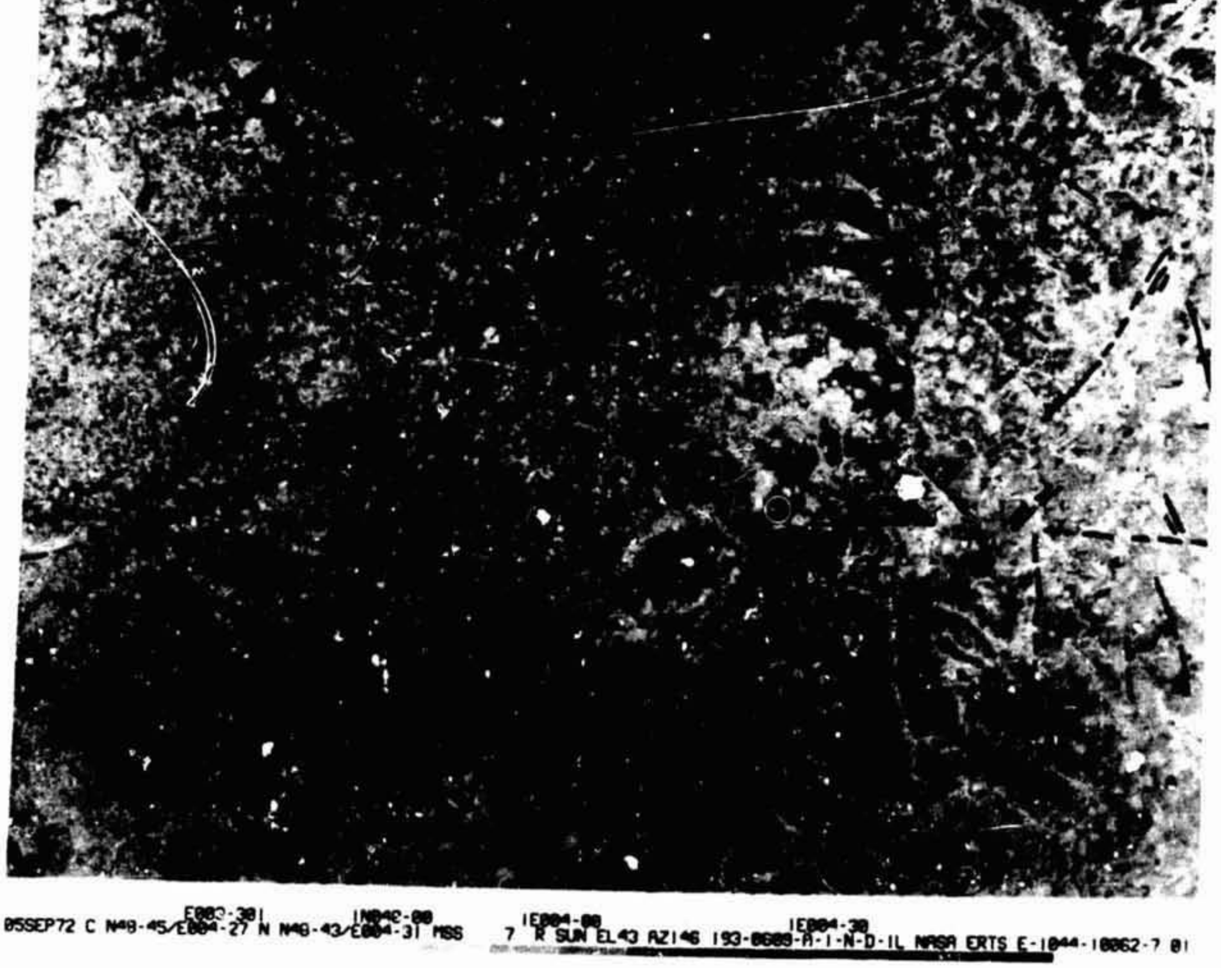
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Figure 3