PROJECT PYRALP

TECTONICS RELATIONSHIPS BETWEEN PYRENEES AND ALPS (SOUTHERN FRANCE)

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Introduction

This report concerns the two-month period of June and July 1974.

Processing of photographic data was continued. It is now far enough along to make possible the use of photos for summer field investigations.

Color composites have been processed from some SL 3 frames.

There are two author-identified significant results in this report.

Data received

70 mm color positive	SL2 Cx - 5	
	SL3 Cx - 10, 26	
35 mm color positive	SL3 Cx - 29, 31, 32, 33	

Investigations conducted during the reported period

1.1 - Investigations of Photos SL3, S. 190 A - Nos. 319, 320, 321.

1.11 - Interpretation of Photo No. 320

Previous investigations needed to be completed by some field observations. Data were collected in June.

This investigation is reported in Appendix 1: "Direct Relations between Paleozoic Trends of Montagne Noire and Tertiary Tectonics in the Pyrenees (Southern France) Revealed by Skylab Photographs."

1.12 - Investigations of Photo No. 321

An interesting result has been obtained with Skylab imagery by J.C. Rivereau (I.F.P. geologist) who was involved some months ago in a detailed photogeological survey over a 600-square-kilometer Permian trough located on the southwestern border of the French Massif Central range. This investigation has already been mentioned in Progress Report No. 2 (April 1974).

Results are reported in Appendix 2: "Improvement in Geological Mapping Using Skylab Photographs."

1.13 - Color composites have been processed using frame No. 321.

Processing was as follows:

1) Positive or negative original film transparencies of selected spectral bands were enlarged to the desired scale (for instance 1:500,000) on film as positive or negative film transparencies. The ratio of enlargement must be very precise in order to obtain a perfect superposition.

2) The edge of enlarged transparencies were perforated together to make sure that superposition would be correct when printing.

3) Color prints were obtained by the direct contact printing of each transparency onto the same color paper print with the help of a DURST color enlarger. The DURST enlarger has a three-colored filter head with variable intensity. A color was assigned to each transparency with specific filter percentage and time exposure. Transparencies were then pin-plugged in a frame and processed one after another onto the same color paper print.

Only two spectral bands were used from Rl 35 (0.6 - 0.7μ) and Rl 32 (0.8 - 0.9μ).

The original product was 70 mm positive and/or negative film.

Ten different compositions were made:

1) Rl 35 Positive Yellow
   Rl 32 Positive Blue

2) Rl 35 Positive Yellow
   Rl 32 Positive Red

3) Rl 35 Negative Red
   Rl 32 Negative Yellow

4) Rl 35 Negative Blue
   Rl 32 Negative Red

5) Rl 35 Negative Red
   Rl 32 Positive Green

6) Rl 35 Negative Green
   Rl 32 Positive Red

7) Rl 35 Negative Red
   Rl 32 Negative Blue
   Rl 32 Positive Green

8) Rl 35 Negative Red
   Rl 32 Positive Green
   Rl 32 Negative Blue

9) Rl 32 Negative Blue
   Rl 35 Negative Green
   Rl 35 Positive Red

10) Rl 32 Negative Red
    Rl 35 Negative Green
    Rl 35 Positive Blue

Some of these color composites were worked up for the investigation reported in Appendix 2.

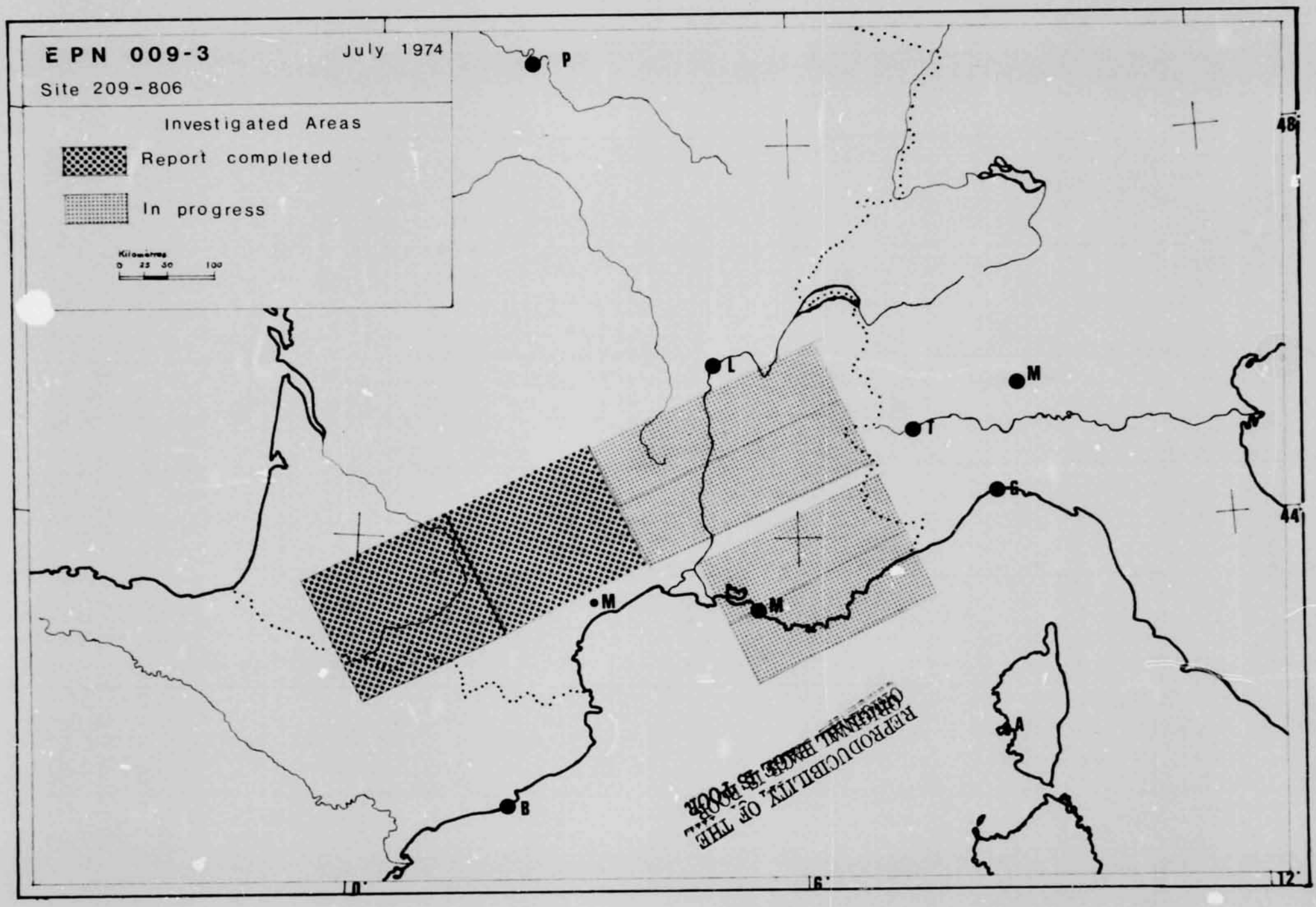
A more careful and systematic study of these products was started during the second half of July. Results are not yet available; they will be reported later.

1.2 - Investigations using SL 3, S 190 A data frames Nos. 75, 76, 77, 78, 79 and 322, 323, 324.

A geological survey using both ERTS 1 and Skylab data was undertaken during July.

The aim is to obtain a better understanding of the significance, in Alpine tectonics, of lineaments already revealed in ERTS 1 imagery and more accurately delineated in SL 3 photos, both B-and-W and color.

Two post-graduate students are working on this survey which will not be completed before December 1974.



Title

Direct Relations between Paleozoic Trends of Montagne Noire and Tertiary Tectonics in the Pyrenees Revealed by Skylab Photographs

by J. GUILLEMOT
(Institut Français du Pétrole)

Abstract

In the Eastern Aquitaine Basin in southern France, investigations using SL 3 photographs from an S 190 A camera reveal a slight line joining a Paleozoic trend of the Montagne Noire massif to a more recent Pyrenean fault zone of Cretaceous to Tertiary age.

According to the interpretation of this line as the superficial geomorphological trace of a deep-seated fault zone, Hercynian weakness lines appear to have played a more important part than previously thought in the building of the Pyrenean range.

The line pointed out, here named "Lezat line", is a trend of small morphological features obvious only in the photographs having the highest resolution (R1 33, 34, 35 and 36).

Introduction

Photographs MSS S 190 A from SL 3, R1 35 No. 320 (Fig. 2) represent part of the eastern Aquitaine Basin in southern France.

The Garonne River draws a large convex curve toward the east (right). The city of Toulouse lies in the middle of the curve (M - 8).

In the south (lower left corner) is part of the Pyrenean range with the Spanish Maladetta massif covered by snow. From the Pyrenean relief the large old (Mio-Pliocene) alluvial fan of Lannemezan extends toward the north filling the concavity of the Garonne River.

In the lower part of the right edge (R - 3) a dark gray-an-black triangle is the western ending of the complicated Paleozoic range of Montagne Noire.

The sketch map in Fig. 3, redrawn from the 1:1,000,000th geological map of France, shows the main geological features seen in the lower part of the photo in Fig. 2. Both Figs. 2 and 3 are on the same scale. Structural features are easily recognizable on the photograph.

In the south lies the partly metamorphosed and intensively folded and faulted Paleozoic rocks of the Pyrenean axial zone (zone primaire axiale). They are bounded by a large thrust fault.

North of this fault is the North Pyrenean Zone (zone nord-pyrénéenne) composed of Paleozoic and Mesozoic rocks, less intensively folded and metamorphosed. The North Pyrenean Frontal Thrust (chevauchement frontal nord-pyrénéen) forms a sharp boundary with the deep Aquitaine Basin filled by Mesozoic and Cenozoic sedimentary rocks.

In the Petites Pyrénées, these rocks are gently folded in two main "en échelon" anticlinal trends (43, 44, 45, 46, 47 in Fig. 1).

Photo-analysis and Field Observation

Photo-analysis was conducted using:

1:500,000th and 1:1,000,000th paper print enlargements for B-and-W photos of Rl 35 and 36

1:1,000,000th paper print enlargements for B-and-W photos of Rl 31 and 32

1:700,000th paper print enlargements for color and IR color photos of Rl 33 and 34.

The geomorphological feature described in this report is seen only in the highest-resolution photographs of Rl 33, 34, 35 and 36. Photographs of Rl 31 and 32, though they give the best image of the land relief, with the Pyrenean mountains quite clear and sharply separated from the Aquitaine Plain, do not bring out the smallest details. The geomorphological feature shown here is emphasized by differences in vegetation which are less obvious in photographs of Rl 31 and 32.

The method used was a conventional photo-interpretation technique.

Fig. 4 is the reproduction of an overlay drawn directly on the SL 3 photograph at 1:1,000,000th scale (lower part only).

The large main features described above are recognizable. Moreover, an interrupted line joining the northwestern edge of the Montagne Noire (P - 4) to the intersection of the Petites Pyrénées folded zone via the Garonne Valley (G - 5) can clearly be seen. This is a new as yet unknown feature.

This line which is quite obvious on SL " images of Rl 33, 34, 35 and 36 is caused solely by some small aligned morphological and agricultural anomalies. The larger morphological anomalies are local trends of the Garonne north of the Petites Pyrénées (H - 5) and a small sinuosity of the Ariège River (L - 4).

At one end in the Montagne Noire (R - 4), the line is a fault which separates Paleozoic rocks in the south from Tertiary conglomerates directly overlying old metamorphosed rocks of probable ante-Hercynian age in the northern area. This was interpreted as a post-Oligocene thrust fault (B. Geze, 1949) recurrence of a Hercynian fault, and still acting during of the Quaternary period (P. Birot et al., 1968).

At the other end the trend of the line is shown by a structural low of the Petites Pyrénées folds where the Garonne flows (H - 5), and by a slight twist in the axis of the anticlines (mainly the Plagne anticline, south of the Garonne, H - 4-5).

Between these two ends, very few data are known from old seismic work. A recently reinterpreted structure is given in Fig. 5 (J. Schoeffler, 1973). In 1955 an oil well was drilled at Lezat (J - 5), close to the line, to explore a structural faulted high. Paleozoic rocks underlying Upper Cretaceous were reached at a depth of 2608 m.

Proposed Interpretation

This morphological line which will be called the "Lezat line" can be interpreted as an old Hercynian trend. In the Montagne Noire it separates two main structural units: the axial Zone composed solely of old metamorphosed rocks and the Southern Slope where Paleozoic sedimentary rocks are intensively folded in a nappe sliding to the south (F. Arthaud, 1970). It was recurring during and after the Cenozoic.

In the Petites Pyrénées Folded Zone the "Lezat line" appears to be the mark of a deep-seated left lateral fault which is responsible for the twist in the anticlinal axis.

The structural contour map (Fig. 5) shows, to the north of the "Lezat line", a complicated faulted zone known as the "Muret fault". The trends of the "Lezat line" and the "Muret fault" are fairly parallel to one another.

Westward the "Muret fault" also seems to introduce a twist in the anticlinal axis (Gensac Anticline trending 60° N). Its prolongation to the northwest is not known.

The "Muret fault" is not apparent in the Skylab photographs as the "Lezat line" is, but it is marked by a local change in the trend of the Garonne south of Toulouse (L - 7). This might be due to the lack of recent displacement along the "Muret fault".

The whole structural feature composed by the "Lezat line", the "Muret fault" and their satellites, observed from the subsurface, is interpreted as the indication in the sedimentary rocks up to the surface in the "Lezat line" of a deep-seated fault zone originating in the basement by Hercynian orogenesis. This deep-seated fault acted mainly as a large strike-slip fault with a left lateral displacement during and after the Pyrenean folding phase.

Importance of This Interpretation

The elongated area described above is part of a wider lineament first identified in ERTS 1 imagery. It can be followed from the northern Appenines in Italy to northern Spain through the southern Alps and the Pyrenean range (J. Guillemot et al., 1973). It is quite obvious in SL 3 photograph No. 319.

This trend has also been pointed out by J. Schoeffler (1965) under the nameof "first order Pyrenean left transcurrent fault".

In Fig. 6 from a recent publication (P. Choukroune et al., 1973) the track of the lineament is quite visible though not emphasized by the authors of the paper. E-W faults crossing and displacing the axial zone and twisting of the schistosity lineations indicate a left lateral displacement. It could be a more important feature in the Pyrenean orogenesis than the North Pyrenean frontal thrust, however, considered by many geologists as the boundary between the Iberic and European plates (P. Choukroune, 1973).

The importance of this lineament, which was not observed in the Toulouse area in ERTS 1 imagery, is thus reinforced.

Conclusion

In the eastern Aquitaine Basin in southern France, investigations using photographs by the S 190 A camera from mission SL 3 give new information where old Hercynian trends play a major part in the edification of the Pyrenean range.

The very light line detected from SL 3 photographs was only possible in rolls No. 33, 34, 35 and 36 which have the best resolution. It cannot be detected on rolls 31 and 32.

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1973 - J. Schoeffler, Rev. I.F.P., Vol. XXVIII, No. 4 and 5

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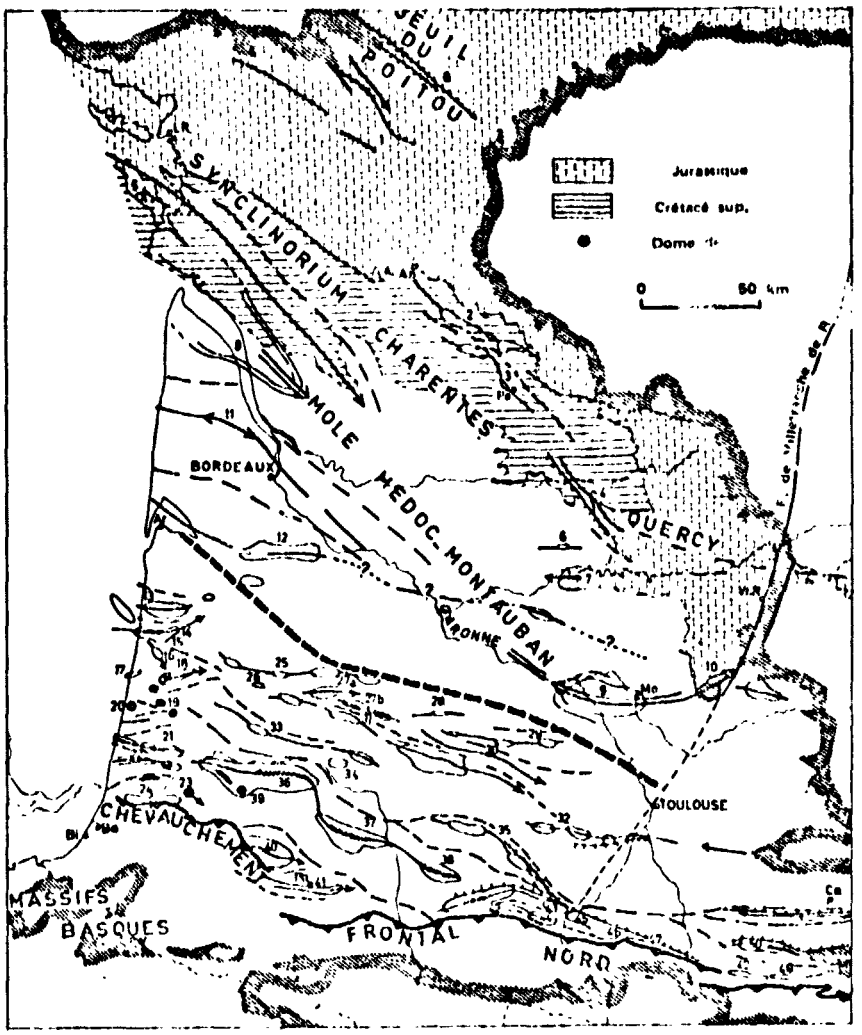


- **Schéma structural du bassin d'Aquitaine.** *Le trait épais tireté marque la limite N du sel du Trias.*

0. Horst de Champagne-St-Hilaire. - 1. Ant. de Montalembert. - 2. Pli de Marcuil. - 3. Ant. de Périgueux. - 4. Dôme de St-Cyprien. - 5. Pli de l'Ile d'Oléron - Jonzac. - 6. Ant. de Sauveterre-la-Lémance. - 7. Dôme de Fumel. - 8. Môle du Médoc. - 9. Môle de Montauban. - 10. Massif de La Grésigne. - 11. Zone haute de Listrac - Blaye. - 12. Axe d'Arcachon - Langon - Bouglons - Clavide et ant. de Villagrain Landiras. - 12bis. Ant de Mano. - 13. Ant. de Parentis et de Mothes. - 14. Axe Mimizan - Pontex - Lucats. - 15. Diapir de St-Paul-en-Born. - 16. Diapir de Bias. - 17. Diapir de Contis. - 18. Pli et diapir de Mézos - Tennedou. - 19. Diapirs des Landes (Boos, etc...). - 20. Diapirs de St-Giron. - 21. Ride salifère de Moliets (ou Léon) - Magesq. - 22. Ride salifère de Sébastopol - Soustons. - 23. Ride salifère de Tercis - St-Pandelon - Benesse-les-Dax, Clermont. - 24. Ant. de Saubrigue - St-Lon. - 25. Ride de Carraté - Labrit - Losse. - 26. Ant. de Garein. - 27. Ant. de Roquefort. - 27 bis. Ant. de Créon. - 28. Ant. de Condom. - 29. Ride d'Av sac. - 30. Ant. de Bordères (Cezan - Lavardens). - 31. Ride de Brocas - Lacquy - Vic-Fezensac - Auch. - 32. Ant. de Polastron - Muret. - 33. Ride de Mont-de-Marsan - Nogaro. - 34. Ant. de Lussagnet. - 35. Ride de St-Médard - Puymaurin - St-André. - 36. Ant. de la Chalosse (ou d'Audignon) - Louer. - 37. Ant. Garlin - Maubourget. - 38. Ant. d'Antin. - 39. Diapir de Bastenne. - 40. Dôme de Lacq. - 41. Ride de Pau - Meillon. - 42. Ant. de Gensac - Brondihan. - 43. Ant. d'Aurignac. - 44. Axe de Lespugne - Charlas, St-Marcet, Preupiary, St-Martory. - 45. Ant. de Plagne. - 46. Ant. de Richou. - 47. Ant. de Mas-d'Azil. - 48. Ant. de Dreuilhe. - 49. Ant. de Puivert. - 50. Ant. de Trézier. - 51. Ant. de la Montagne Noire.

Fig. 1 - General structural sketch map of Aquitanian Basin (From E. Winnock, 1974)

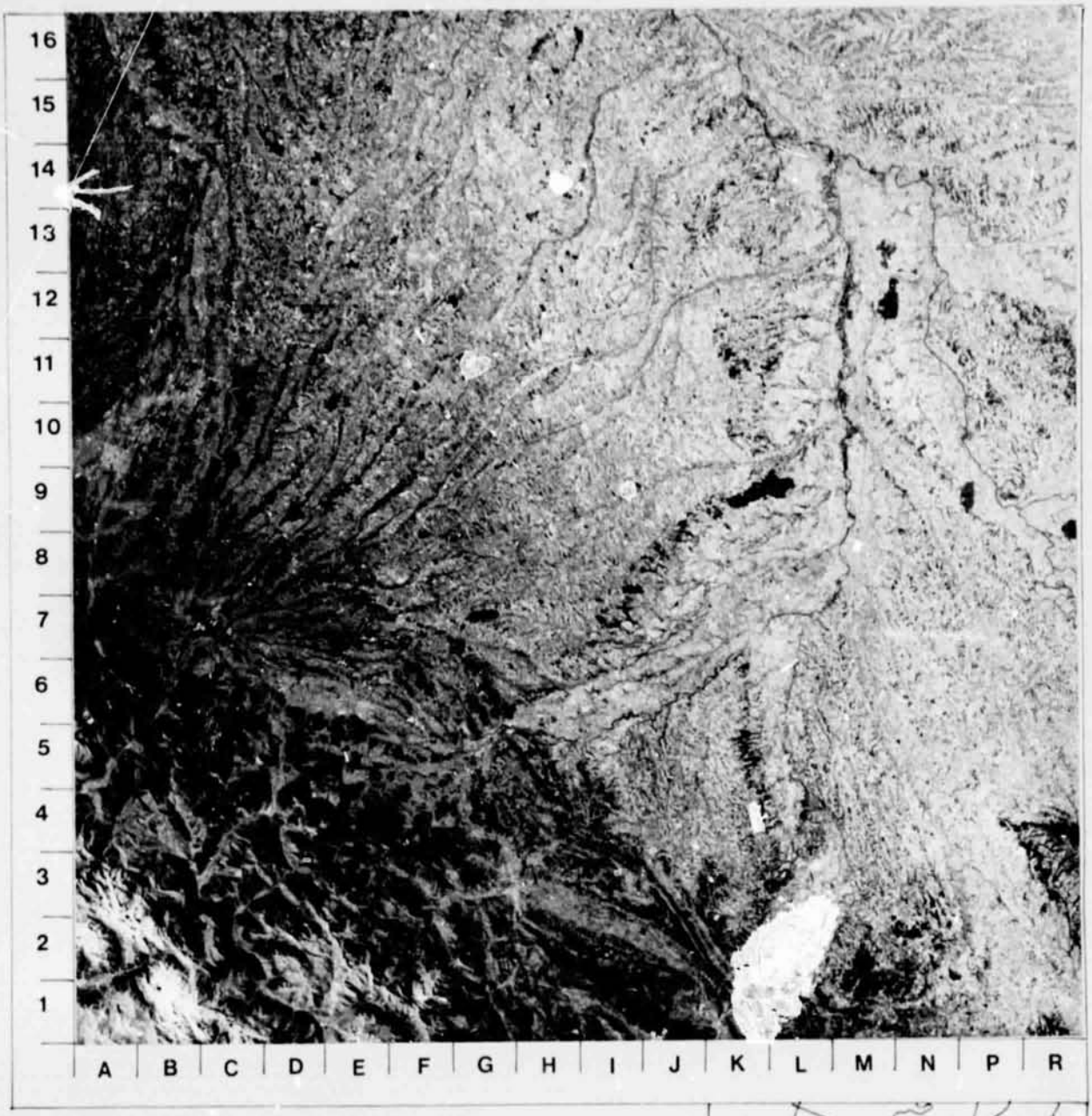


Fig. 2 - Skylab 3
R1 35 - No. 320
Sept. 11, 1973
Scale: 1:1,000,000th

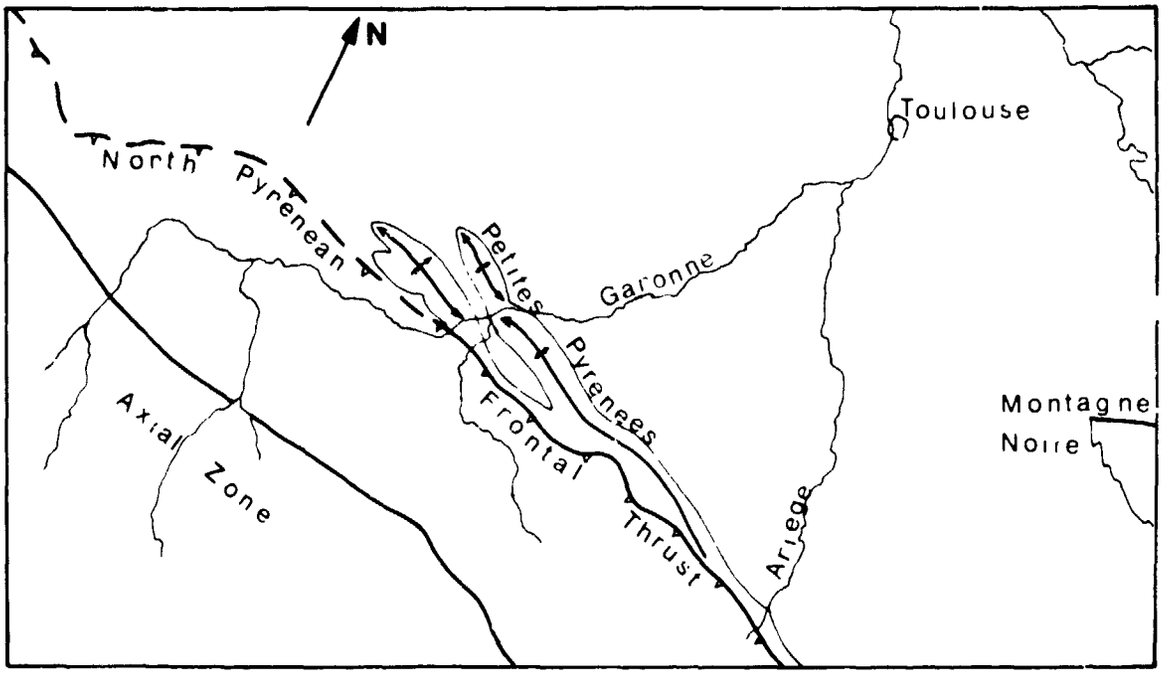


Fig. 3 - Structural sketch map
Scale: 1:1,000,000th

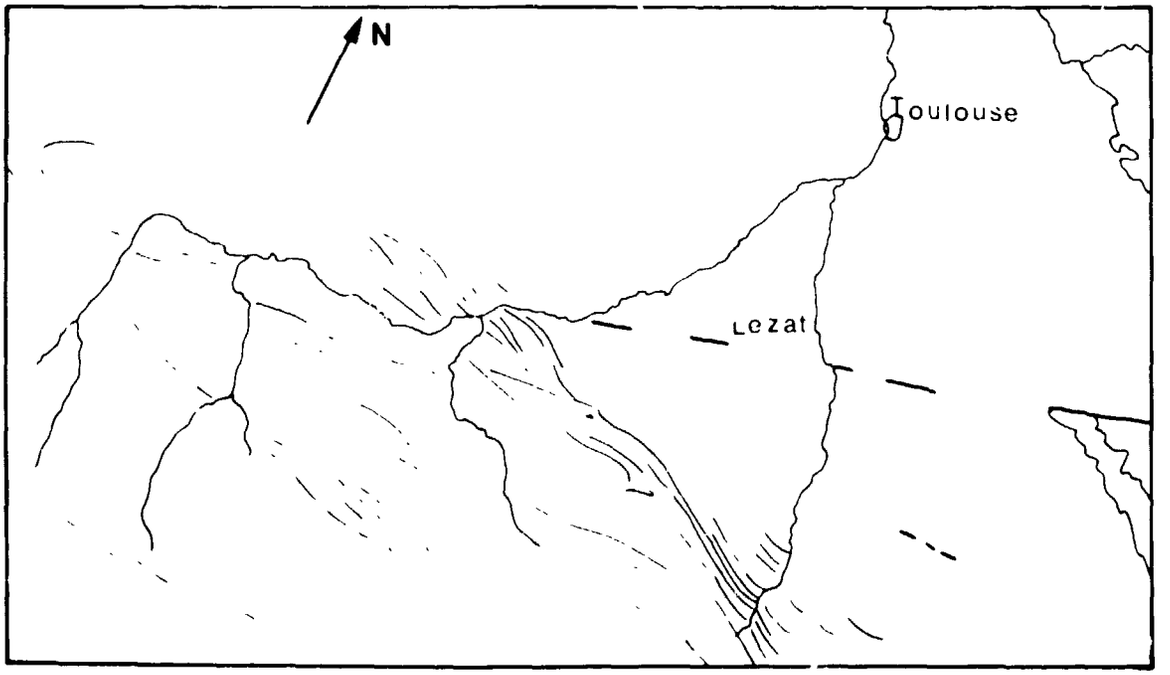


Fig. 4 - Overlay of photograph fig. 2 (lower part)
Scale: 1:1,000,000th

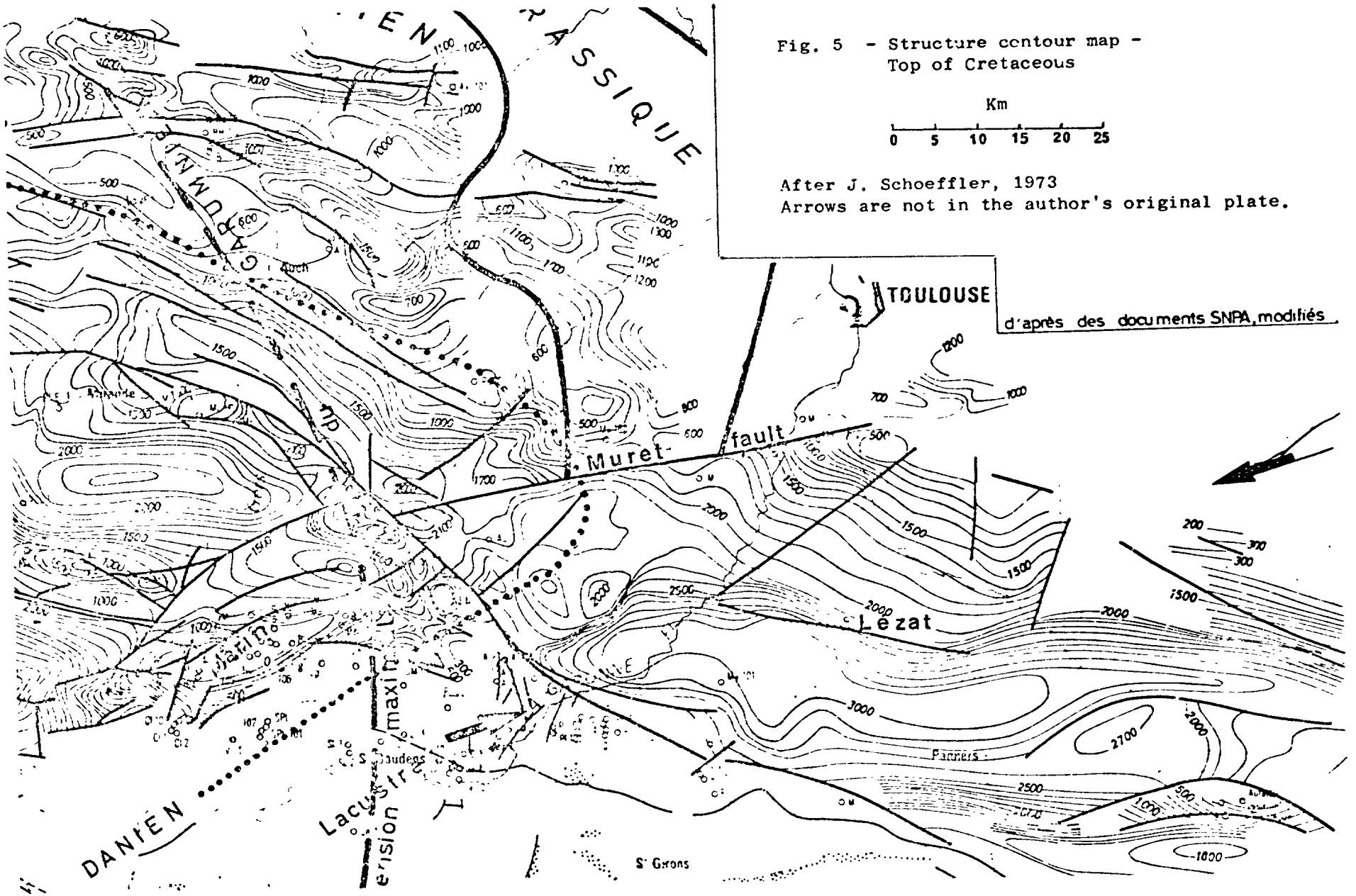


Fig. 5 - Structure contour map - Top of Cretaceous

After J. Schoeffler, 1973
Arrows are not in the author's original plate.

d'après des documents SNPA, modifiés

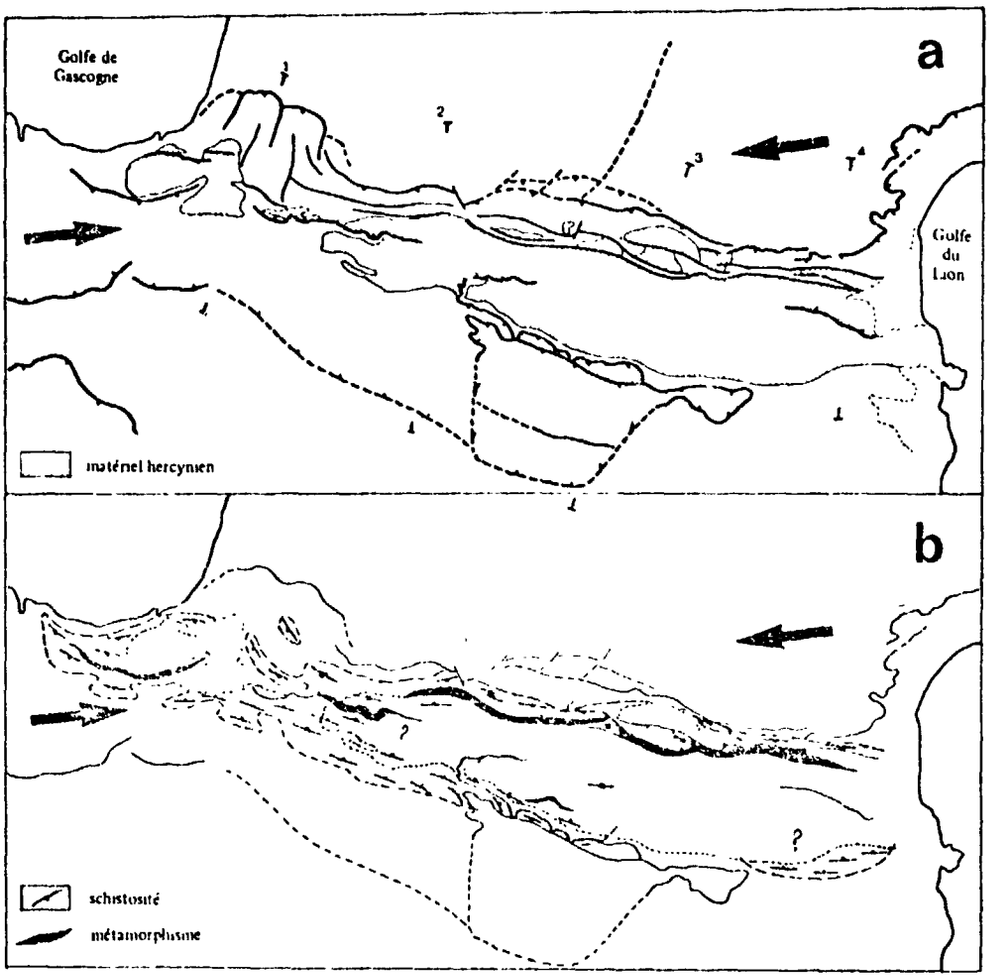


Fig. 6 - Sketch maps of Pyrenean range
a - general structure
b - schistosity and metamorphism
(From P. Choukroune and al., 1973)

- Arrows indicate the trend of the lineament described in the report - (They are not in the author's original figure).

Title

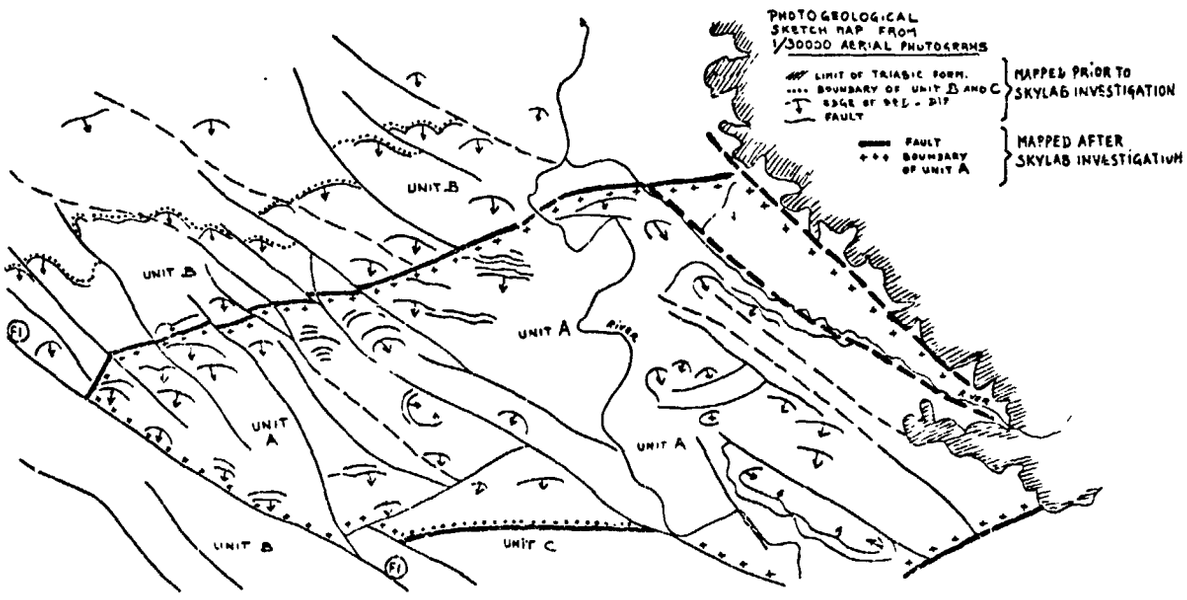
Improvement in Geological Mapping Using Skylab Photographs

by J.C. RIVEREAU
(Institut Français du Pétrole)

An interesting result was obtained with Skylab imagery in a detailed photogeological survey over a 600-square-kilometer Permian trough located on the southwestern border of the French Massif Central range. Conventional air photographs at 1:30,000th scale and field checks were used to carry out the geological mapping of the area. As both ERTS and Skylab imagery were available over the area studied, it was decided to use them as a complementary approach to the survey. Actually the study of satellite imagery and mainly Skylab photos resulted in a complete new interpretation of part of the trough.

This Permian basin is filled up with a typical continental sedimentation that includes mainly conglomerates and poorly sorted sandstone. Finer sediments such a siltstone and claystone may also occur. The age of the formations is Autunian and Saxonian. Sudden variations of lithology in both vertical and horizontal directions are common and make it difficult to bring out clear stratigraphic units.

In the central-southern part of the basin, a well bedded unit (A) composed of fine sediments (siltstone and clayey sandstone) is surrounded by poorly bedded sandstone to the west and north (unit B) and conglomerates to the south (unit C). Unit A has thusfar been considered by field geologists to be one of these lateral lithological changes with only the western boundary being structurally controlled by a fault running NW (F 1). The conventional photogeological study provided better and more precise mapping of the area and showed particularly that unit A was quite homogeneous and that it was crossed by numerous faults having a NW trend and causing small displacements of bedding. But, due to (1) the same strike of bedding of units A and B (2) the same dislocation of bedding caused by the northwesterly running faults, nothing else was suspected about the relationship between units A and B.



Only the synoptic view of Skylab (and ERTS to a lesser degree) imagery showed the clearcut regular pattern of unit A which is bounded in all directions by straight lines and appears with a peculiar, polygonal shape. From these images it is obvious that the whole unit A is structurally controlled by faulting. It is now thought that unit A occupies a collapsed part of the basin in which the top sediments of the trough have been preserved from erosion. Therefore unit A may no longer be chronologically correlated with unit B and no longer appears as a local lithological variation of B. It is probable that unit A is younger than unit B and has been removed from top of B in other parts of the area and only preserved in the collapsed area.

Drilling and geophysical surveys are now under way in the area, and we will see whether their results confirm this hypothesis.

We would like to emphasis that, although the feature is visible on ERTS images (1242-10085), it really stands out only in Skylab photographs thanks to a very well defined spectral contrast in S 190 A Rl 34.

It has been enhanced on various color composites of Rl 35 and Rl 32 of S 190 A, made by mixing either positive or negative transparencies.

From investigation made to obtain a better understanding of the outstanding feature, it appears that the features that enable unit A to be discriminated from surrounding units are: morphology and vegetal cover. As a matter of fact, the Saxonian sandstones (unit B) and conglomerates (unit C) which surround unit A are poorly bedded and rather massive and have resulted in a landscape of rounded elongated hills with mainly timber cover (no more than 20% of cultivated areas), whereas the silty well-bedded unit A gives a flatter area with 100% of the land devoted to crops and meadows. The integration of both these morphological and land use characteristics by the synoptic view of satellite imagery enables the phenomenon to be perceived with real accuracy.

On ERTS images, unit A is detected only by morphological features and there is no tonal difference between units even when using color composite techniques. Thus attention is not paid to the feature and only a careful study enables it to be detected. This difference between Skylab and ERTS images may be due partly to seasonal differences in vegetal cover (the ERTS image was taken in March and the Skylab photos in September) or the differences in atmospheric conditions, but the better information gathered on Skylab data comes mainly from:

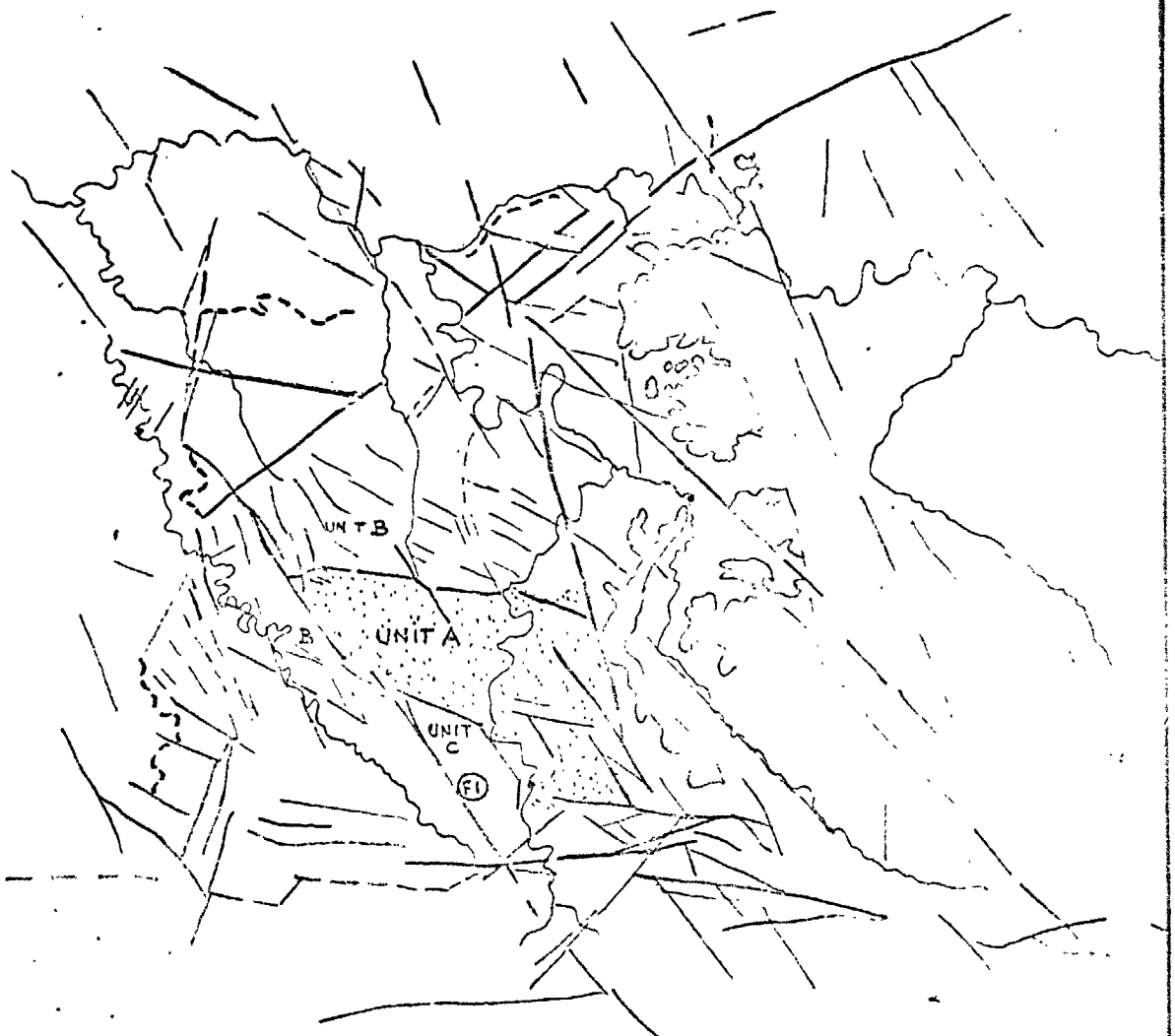
- better ground resolution;
- the higher quality of Skylab color and MSS photographs, particularly as far as spectral response is concerned, compared with the ERTS scanning system.

Skylab's best performances have been obtained with the following products :

S 190 A (No. 321) Rl 35

S 190 A (No. 321) Rl 34

Part of SL 3 S 190A - RL 35-321
- enlarged at 1:320,000 scale



SKYLAB INTERPRETATION OF THE PERMIAN TROUGH WITH S190 A AND S190 B - SCALE 1/320,000

FAULT AND LINEAMENT

LIMIT OF TRIASIC FORM.

LIMIT OF PERMIAN TROUGH VISIBLE ON SKYLAB IMAGERY

AREA OF UNIT A AS DISCRIMINATED FROM SKYLAB IMAGERY