Atti Accademia Nazionale dei Lincei

Classe Scienze Fisiche Matematiche Naturali

# Rendiconti

Claudio Ebblin

## Tectonic Lineaments in Karakorum, Pamir and Hindu Kush from ERTS Imageries

*Atti della Accademia Nazionale dei Lincei. Classe di Scienze Fisiche, Matematiche e Naturali. Rendiconti, Serie 8*, Vol. **60** (1976), n.3, p. 245–253.

Accademia Nazionale dei Lincei

<http://www.bdim.eu/item?id=RLINA_1976_8_60_3_245_0>

Atti della Accademia Nazionale dei Lincei. Classe di Scienze Fisiche, Matematiche e Naturali. Rendiconti, Accademia Nazionale dei Lincei, 1976.

## SEZIONE II
### (Fisica, chimica, geologia, paleontologia e mineralogia)

---

**Geologia.** — *Tectonic Lineaments in Karakorum, Pamir and Hindu Kush from ERTS Imageries.* Nota di CLAUDIO EBBLIN, presentata (*) dal Socio A. DESIO.

RIASSUNTO. — Su una carta del Karakorum, Pamir e Hindu Kush sono state riportate le lineazioni tracciate da immagini di satelliti della zona. Tali immagini furono fornite dall'Earth Resources Organization System che le aveva ottenute dai Earth Resources Technology Satellites (ERTS).

La carta offre dati nuovi e oggettivi sull'estensione e la localizzazione di lineamenti tettonici nell'area in considerazione. Si sottolinea comunque che una futura interpretazione geologica di questi dati deve tenere in considerazione il fatto che, dovuto ad una illuminazione particolarmente favorevole, le tracce di superfici strutturali che sono subverticali in direzione approssimativamente E-W sono quelle che risultano più evidenti sui fotogrammi. Inoltre si nota che le grandi discontinuità strutturali risaltano in modo particolare in aree di forte sollevamento recente mentre quelle minori sono più evidenti dove c'è una alternanza di zone di erosione e di deposizione.

### INTRODUCTION

The geodynamics of a mountain system can be best understood if a comparison is made between geological evidence, which supplies information about older deformations, geomorphological evidence, which gives a clue to recent movements, and geophysical evidence, which suggest the trend of possible future movements.

Occasionally these three methods of investigation collect data which are in disagreement with each other thus testifying that the characteristics of the deformation that the orogenic belt have undergone have changed and/or are changing.

This is the case in the area of the Himalayan Syntaxis (Marussi, 1976) where the superficial structures of the Earth's crust as depicted by geological mapping (Wadia, 1931; Desio, 1964; 1965; 1974; 1976; Gansser, 1964; Fuchs 1975) do not match the configuration of the deeper sections of the crust obtained from geophysical investigations (Marussi, 1963).

Since the detailed study of the Himalayan orogenic belt forms a relevant part of the current International Geodynamic Project established by the International Council of Scientific Unions at the request of the International Union of Geodesy and Geophysics and of the International Union of Geological Sciences, the finding of points of agreement between the superficial structures and those revealed at depth by geophysical surveys is believed to be a valuable contribution to the Project.

(*) Nella seduta del 13 marzo 1976.

A useful approach to provide a link between geological and geophysical evidence was thus believed to be the geomorphological examination of the area.

The intent of the present contribution is to supply some objective data concerning the extent and location of tectonic lineaments in that area.

This is made possible by the recent availability of ERTS imageries from which it is possible to detect the very largest structural features which probably extend to great depths and to compare them with the minute linear elements which are probably related to the geological structures as they appear at the surface.

Indeed the length of a line on the Earth's surface suggests more than its possibly striking appearance, that it represents the trace of a surface which must extend in depth since it is unlikely that a structural surface be developed to an extreme in one dimension only.

Satellite imageries have proved to be very useful for the identification of previously unmapped features of regional extent since the single, synoptical view possible because of the orbital height permits a better interpretation than a mosaic of many aerial photographs taken with diverse illumination. Furthermore being able to see on a single image whether the major lineaments are discordant with the minor ones is thought to be useful in the reconstruction of the history of the deformation of the area.

## The Earth Resources Observation System

Data from the Earth Resources Technology Satellite, ERTS, from the Earth Resources Experiment Package of Skylab and from NASA's Aircraft Program are all used by the EROS programme.

The first ERTS observatory was launched on July 23, 1972. Its orbit is polar, about 900 km above the Earth and the images returned are sensed by a three-camera television system (Return Beam Vidicon) and a four-channel scanning radiometer (Multi-Spectral Scanner). The satellite completes its orbit every 103 minutes and sends coverage of the same spot on Earth every 18 days.

The imageries are first processed at the Goddard Space Flight Center, NASA Data Processing Facility and subsequently supplied to the EROS Data Center in Sioux Falls, South Dakota. After processing the data are either system-corrected images (bulk processed) or scene-corrected ones (precision processed); the former in the form of 70 mm film, the latter on 240 mm film on a scale of 1 : 1 000 000.

Copies of the system-corrected images are available from the EROS Data Center on contact scale (1 : 3 369 000) or on a scale of 1 : 1 000 000 whereas copies of the scene-corrected images may be obtained on scales 1 : 1 000 000 or larger only.

## COMPILATION TECHNIQUE

The imageries used for the present work (fig. 1) were scene-corrected. Most of the tracing was done from 45 cm × 45 cm images on a scale of 1 : 500 000 obtained from the Multi Spectral Scanner in band number 6; however 90 cm × 90 cm images on a scale of 1 : 250 000 in band number 7 (infrared) were also available for detailed observations.

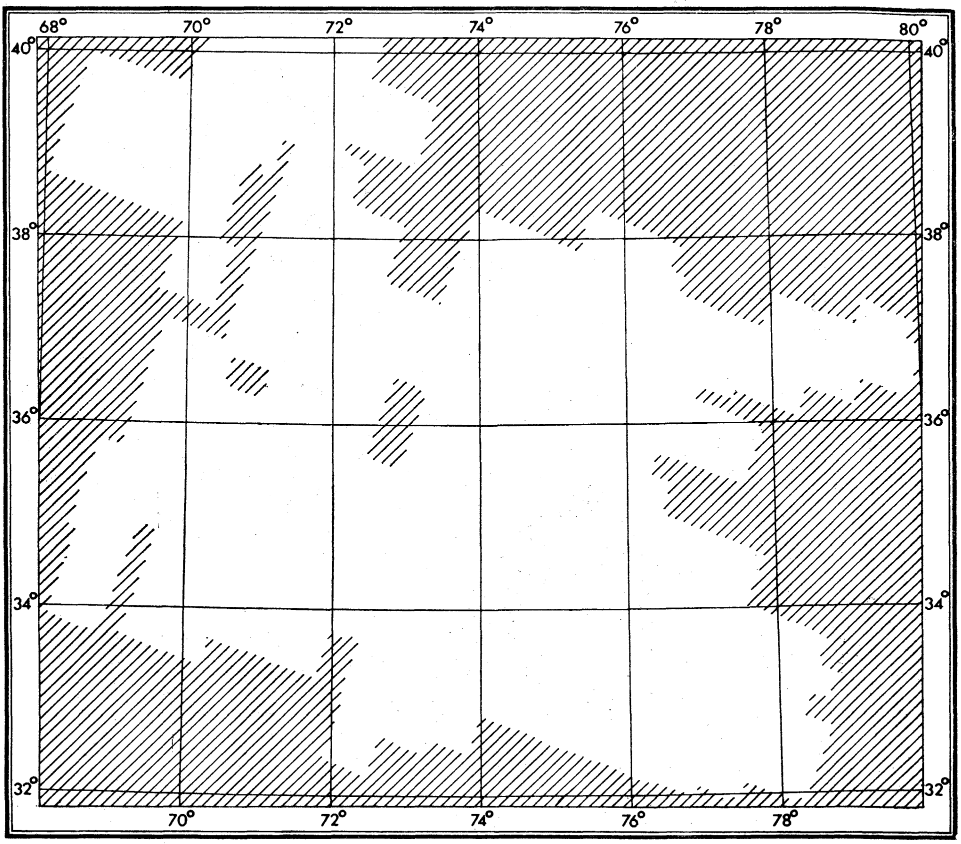



Fig. 1. - ERTS imageries coverage used for the present work (white area).

All the lineaments noticeable on the imageries were traced onto separate sheets of transparent paper with the help of a light-table. The sheets of transparent paper were then photographed and printed on transparencies on a 1 : 1 000 000 scale. Such transparencies were then assembled on a grid in the polyconical projection of the area of interest.

The final mosaic was successfully retraced on a new, large sheet of transparent paper where each single line that had a slightly diverse geographical location in different, neighbouring sections of the mosaic was relocated according to the hydrographic system of the area which had been traced from the USAF Pilotage Chart on a scale of 1 : 500 000 (annexed Plate).

Obviously on ERTS imageries it is impossible to distinguish between lineaments of different nature, e.g. it is often unclear whether any given lineament represents the strike of the compositional banding of the rocks or whether it marks a cleavage or a sedimentary or structural discontinuity. Such a distinction could be made solely in the case of a discordance between the various patterns.

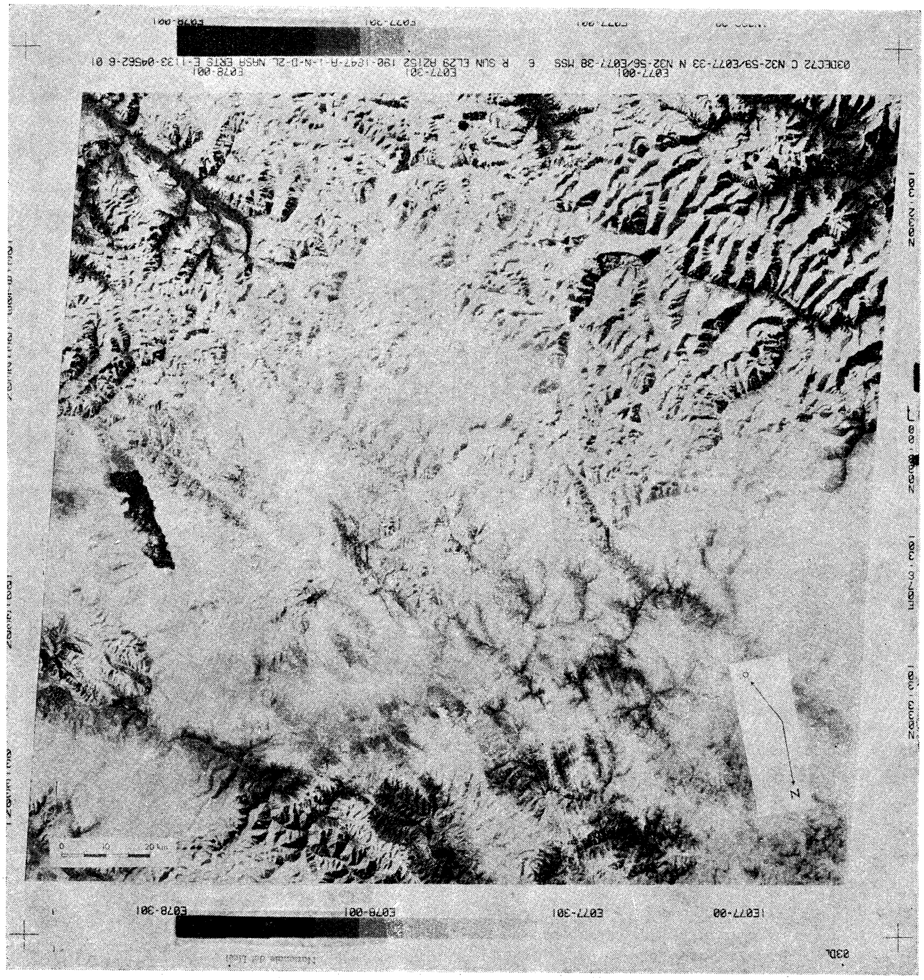
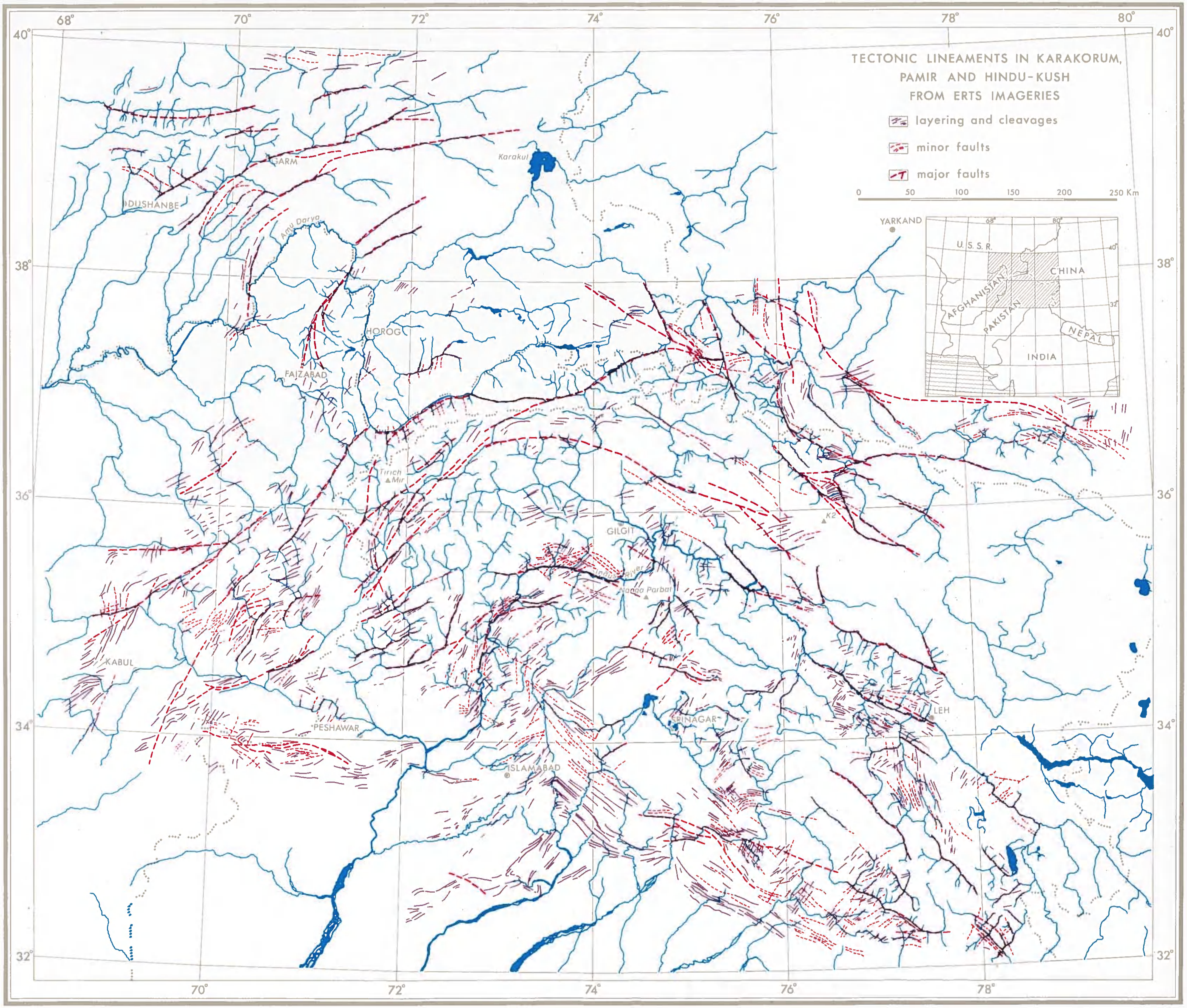



Fig. 2. - ERTS imagery of an area about 33° N and 77.5° E. In the upper left corner the NE-tributaries of a rectilinear valley appear to have cut deeper valleys than the corresponding SW-tributaries. This effect might be the consequence of an uplift of the area NE of the main valley which might mark the trace of a fault connected with such uplift.

Thus here all detectable linear features have been grouped into three diverse classes according to their appearance.

Small, closely spaced lineaments, perhaps representing compositional banding or cleavage, have been traced as thin purple lines. Larger lineaments, usually isolated, have been thought to be the trace of minor faults and have


TECTONIC LINEAMENTS IN KARAKORUM, PAMIR AND HINDU-KUSH FROM ERTS IMAGERIES
layering and cleavages
minor faults
major faults
0 50 100 150 200 250 Km
YARKAND
U.S.S.R.
CHINA
AFGHANISTAN
PAKISTAN
NEPAL
INDIA
GARM
DUSHANBE
Karakul
Amu Darya
HOROG
FAIZABAD
Tirich Mir
GILGIT
Indus River
Nanga Parbat
K2
KABUL
PESHAWAR
ISLAMABAD
SRINAGAR
LEH

been drawn in red. The same colour was used to mark the largest linear features, generally obtained from hydrographic or orographic peculiarities and supposed to represent the trace of major faults.

It is most evident that the degree of detectability of a linear feature will depend greatly on two factors: the differential erosion related to it and a favourable illumination.

Fig. 3. - ERTS imagery of an area about 32.7° N and 73° E depicting some faults with some apparent horizontal displacement.

Obviously planar structures which are subvertical will be detected more easily than those which are subhorizontal; at the same time in the case of faults a large displacement resulting in a strong vertical or horizontal component will facilitate the discovery of the structure. Moreover lineaments developed roughly in an east-westerly direction will be seen more readily than those oriented N–S since the illumination from the South will enhance the topographical contrast in the former case much more than in the latter one.

However more often the vertical displacement of a major fault is detected by the different erosional rates occurring on the opposing sides of the fault and by the presence of cones of sediments on the down-thrusted side. Indeed the action of the uplifted streams is much more vigorous and the valleys will be more deeply cut on one side (fig. 2; all ERTS imageries are printed upside-down to obtain the proper three-dimensional effect) while on the other a deposition of detrital sediments can occur.

Fig. 4. – ERTS imagery displaying major rectilinear valleys which are believed to have developed along large discontinuities in the rocks. The area is located about 36° N and 70° E.

Furthermore the horizontal components of throw appear instead quite evident due to the displacement of hydrographic or orographic lines and of geological layering (fig. 3).

Naturally large faults, especially where they are concordant with the layering of the rocks, are best detected owing to the fact that the hydrographic net is strongly controlled by such features and that the course of major rivers in these cases is strikingly rectilinear (fig. 4). These peculiarities appear most evident in areas of strong recent uplift, i.e. where most of the area is being eroded (fig. 5); in such areas however it is usually difficult to trace the orientation of minor structures like the layering of the rocks or their cleavage.

Fig. 5. – ERTS imagery of a mountainous area about 34.5° N and 69.5° E in which several major faults appear quite evident.

On the contrary the areas which exhibit the most favourable conditions for the study of the latter minor lineaments are undoubtedly those where narrow zones of erosion are tightly alternated with zones of deposition (fig. 6). However in these areas large faults, especially if concordant with the minor structures, are not always detectable since they are usually covered by fresh sediments.

Obviously all the considerations above ought to be taken into account when the information supplied in the present paper is used to propose a tectonic interpretation of the area.

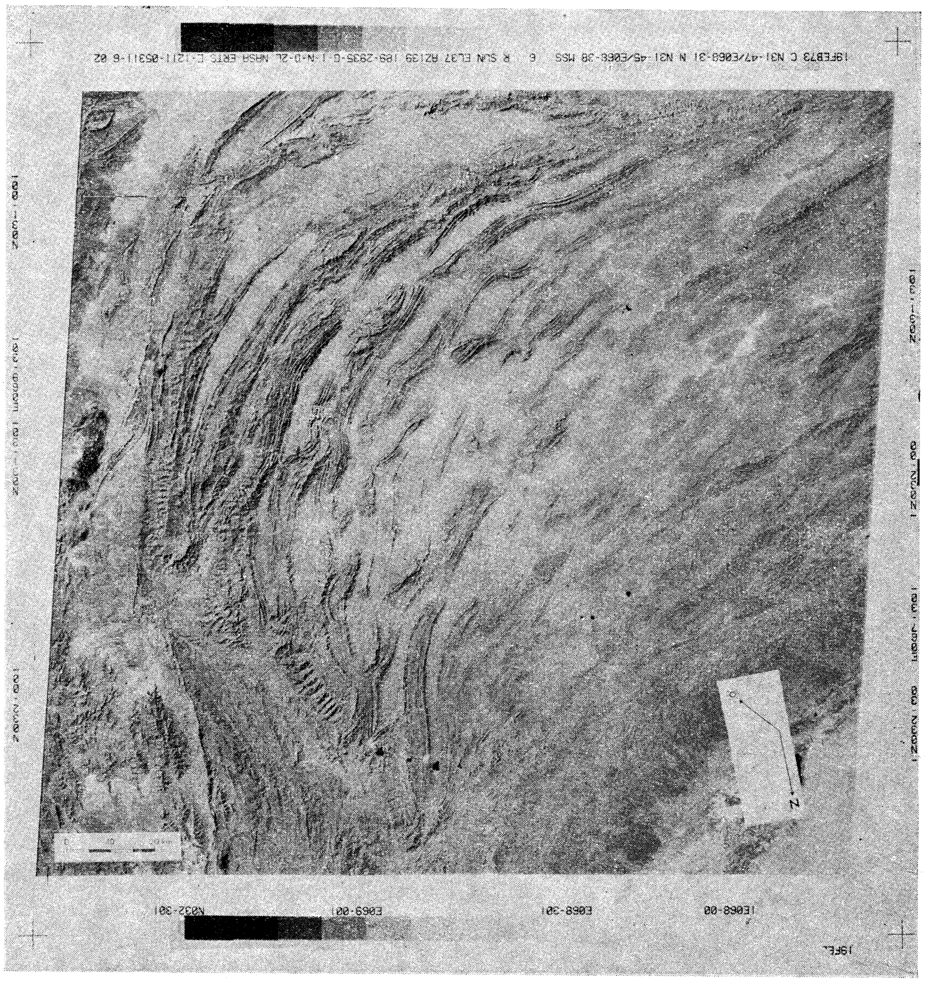


Fig. 6. – ERTS image of an area about 32° N and 68.5° E which was not used in the present work but shows how clear lineations can appear in an area of alternated erosion and sedimention.

*Acknowledgments.* I wish to thank Prof. Marussi for his constant encouragement and interest and both him and Prof. Desio for critically reading the typescript. Thanks are also due to Dr. Bartole and to Mr. Cavicchi for the drawing of the map. Furthermore I am greatly indebted to the Accademia Nazionale dei Lincei for its moral and financial support.

## BIBLIOGRAPHY

DESIO A. (1965) – *Sulla struttura tettonica dell'Asia centrale*, « Acc. Naz. Lincei, Rend., Cl. Sc. fis., mat. nat. », ser. VIII, *38*, (6), 780–6.

DESIO A. (1964) – *Tectonic Relationship between the Karakorum, Pamir, and Hindu Kush (Central Asia)*, 22nd Intern. Geol. Congr., India, part II, section II, 192–213.

DESIO A. (1974) – *Karakorum Mountains, in Mesozoic–Cenozoic Orogenic Belts*. The Geological Society Special Publication, n. 4, 255–66.

DESIO A. (1976) – *Some Geotectonic Problems of the Kashmir Himalaya–Karakorum–Hindu Kush and Pamir Area*, « Acc. Naz. Lincei Proc. », in press.

FUCHS G. (1975) – *Contributions to the Geology of the North–Western Himalayas*, « Abh. Geol. B. A. », Bd. *32*, Wien.

GANSSER A., (1964) – *Geology of the Himalayas*, Interscience, London.

MARUSSI A. (1963) – *Le anomalie di gravità lungo la catena del Karakorum–Hindu Kush*, « Acc. Naz. Lincei, Rend., Cl. Sc. fis., mat. nat. », ser. VIII, *35* (5), 198–210.

MARUSSI A. (1976) – *Gravity in the Karakorum*, in *Geotectonics of the Kashmir Himalaya–Karakorum–Hindu Kush–Pamir Orogenic Belts*, « Acc. Naz. Lincei Proc. », in press.

WADIA D. N. (1931) – *The Syntaxis of the North–West Himalaya: Its Rocks, Tectonics and Orogeny*, « G.S.I. Rec. », Calcutta.