Title of Investigation: MAPPING OF LITHOLOGICAL UNITS, STRUCTURAL UNITS AND SURFACE DRAINAGE USING SKYLAB-DATA

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2.1.2 Index

Mapping of regional geological units (lithology, tectonics) and surface drainage in the Asmara/Zula Bay-region of NE-Ethiopia.

2.1.3 Technical Approach and Task Description

The purpose of the investigation has been to investigate the applicational potential of satellite-photography in a program of geological mapping in Ethiopia. The synoptical coverage of Skylab-photography, the use of color and color-infrared photography was thought to improve and speed up the process of regional geological mapping in the test area. Structural and lithologic maps of selected areas of Ethiopia were to be prepared. Ground control was to be provided by field observation in selected areas and by existing maps. A comparison was to be made with geological maps compiled from ERTS 1-data.

2.1.4 History of Investigation

Until 1972, a major problem existed when interpretations of the Afar-Triangle/Ethiopia and its structural genesis were attempted. Up until this time, all detailed geological, petrological and geophysical investigations had been made in small, widely distributed parts of the Afar and adjacent regions along several traverses. These investigations had been performed by teams from several nations and quite often problems arose when correlations of the data from the various (often isolated) parts of the Afar had to be made, for wide areas still remained unmapped. Gaps between the various mapped areas made the interpretation of known data difficult. Here, ERTS 1 offered a unique chance to get synoptical coverage of the Afar-Triangle and its geological framework by the satellite's sensors and to use ERTS 1-imagery for lithological and structural mapping on a unified basis at an adequate scale. Under ERTS 1-proposal Sr 351 an area covering more than 600 000 square kilometers has been mapped from ERTS 1-imagery. A lithological map, a map of surface structures and

a map of surface drainage (each at a scale of 1:1 000 000) were prepared from ERTS-data as well as a photomosaic covering the test area. A comparison between the ERTS-data maps and the Geological Map of Ethiopia published in 1973 at a scale 1:2 000 000 revealed, that the latter needs a considerable amount of updating.

The results of the geological evaluation of the ERTS-imagery of the Afar and its geological frame had proven the usefulness of this type of satellite data for projects of regional mapping. The evaluation of ERTS-imagery also resulted in new aspects of the structural setting and the tectonic development of the Afar-Triangle, one of the earth's most interesting areas under aspects of plate-tectonics (see final report ERTS 1 Sr 351).

The objective of the Skylab-Proposal had been to find out, if the data from Skylab's photographic experiments 190 A and from the experiment 192 (MSS) would give us an even better basis for compiling regional geological maps. The intention had been to compare ERTS 1- and Skylab-data with regard to their usefulness to regional mapping (lithology, tectonics, surface drainage) in selected parts of the test area.

2.1.5 Techniques and Procedures Used

Conventional techniques applying the mirror stereoscope have been used to the geological evaluation of the black and white, color and color-infrared Skylab-photos. The possibility of viewing the photos stereoscopically proved to be of high advantage to the evaluation procedure (as compared with the evaluation of ERTS-imagery, where threedimensional observations had not been possible).

A comparison made between the various photographic products of experiment 190 A with regard to their usefulness to thematic mapping indicates, that 5-inch color-infrared photography provided the best usable basis for mapping lithological and structural units, surface drainage and land use.

2.1.6 Skylab Data obtained

The Skylab data reached us in good condition. No damage was to be reported.

190 A-photography and 192-imagery obtained by us cover only a very small part of the original test area. Out of 24 obtained photographic scenes only three were free of cloud coverage or do show minimal cloud coverage. Therefore the investigation had to be limited to a very small area.

The MSS-scenes obtained by us cover small areas in the south of the area covered by 190 A-photography. The MSS-images are of poor quality and proved not to be useful for geological evaluation.

2.1.7 Ground Activities

Field observations and measurements in parts of the area covered by Skylab-photography had been made by members of the Clausthal-Institute along several traverses in 1969 under the international Upper Mantle Project. Nearly complete coverage of the test area by aerial photography had been available to the investigators.

2.1.8 Discussion of Problems Encountered

The main problem of the investigation reported here has been that most of the 190 A-scenes obtained by us did show high to complete cloud coverage. Therefore, only 3 out of 24 scenes could be used for the evaluation test.

Another problem had been, that the usable photographic scenes cover only a very small part of the original test area.

Finally, the MSS-scenes proved to be of poor quality. They could not be used for correlation tests.

2.1.9 Results and Findings of the Investigation

Three cloudfree scenes covering the Asmara region of the northeastern Ethiopian Highlands and the areas around Zula Bay (Red Sea) have been evaluated under geological aspects. Both the color and the color-infrared versions of 5-inch photography were tested for resolution and geological information. The results of the comparison indicate, that the color infrared photos do show better resolution. They also provide more usable information on lithology, tectonics, surface drainage, land use, than the color photos. The possibility of viewing the Skylab-photos stereoscopically proved to be an important advantage to the evaluation process. This refers especially to the analysis of the geomorphological history of the test region. Because of high quality (resolution, contrast, color) the Skylab-photos proved to be en excellent basis for regional mapping, for regional geological analysis. The following maps have been prepared from the geological evaluation of scenes 363-365: a map of surface drainage (Fig. 1), a map of lithological units (Fig. 2), a map of tectonic structures (Fig. 3).

The map of surface drainage (Fig. 1) indicates that the careful evaluation of Skylab-photography leads to the compilation of a very detailed map of the surface drainage network. Reliable information on watersheds and on the position and size of drainage basins - an information required for regional water inventories - could be taken from the map shown in Fig. 1. This type of information plus the data on the lithology and the structural setting of the area (also obtained from the evaluation of the Skylab-photos) would provide the essential part of information needed by the hydrogeologist involved in a project of regional water inventory.

The geological evaluation of the Skylab-scenes resulted in a rather detailed lithological map of the test area (Fig. 2) 16 lithological units could be differentiated and outlined by criteria of conventional photogeological criteria. They include two types of basement rocks (metamorphites, granites), seven

types of sedimentary rocks and 6 units of extrusive rocks. A regional peneplain cutting the upper basement and an area of laterite cover could be oblined.

The classification of the above rock units (lithologically and stratigraphically) became possible by correlating the Skylab-Data with data known from field observation and from photogeological work.

Fig. 3 shows the surface traces of joint and fault systems of the test area mapped as photolineations in the Skylab-photos. The evaluation of those photos has shown, that Skylab-Photos because of their high areal coverage plus high spatial resolution provide essential information on the regional pattern of fracture and fault systems as well as on patterns of local jointing and faulting. It is this type of structural information which is needed by the geologist working in projects of hydro-geology, mineral prospecting, engineering geology.

Even though the investigation had to be limited to a limited area of northeastern Ethiopia, the above results have proven Skylab-photography to provide a useful and reliable basis for regional geological mapping and for analyses of regional geology in landscapes similar to our test area. Because of larger scale, higher spatial resolution and the possibility of stereoscopically viewing Skylab-photography is to be seen superior to ERTS-MSS-imagery. Skylab-photography provides more detailed information than could be obtained from ERTS-imagery.

The MSS-imagery we obtained from experiment 192 covers two scenes in the southern part of the test area. The MSS-images are of poor quality since scan lines mask the scenes heavily. This effects spatial resolution and interpretability of the MSS-imagery. Also of disadvantage to the planned investigations has been the fact, that the MSS-scenes were taken over terrain being quite monotonous lithologically. The MSS-scenes therefore

did not provide a qualified basis for comparisons of the data content of Skylab-photography and ERTS-imagery.

ERTS-MSS-imagery covering the same areas as the Skylab-MSS-scenes at the same scale is much superior in image quality and interpretability to the imagery from experiment 192 for our test area.

2.1.10 Recommendations with Respect to the Utilization of Skylab-data for Practical Applications

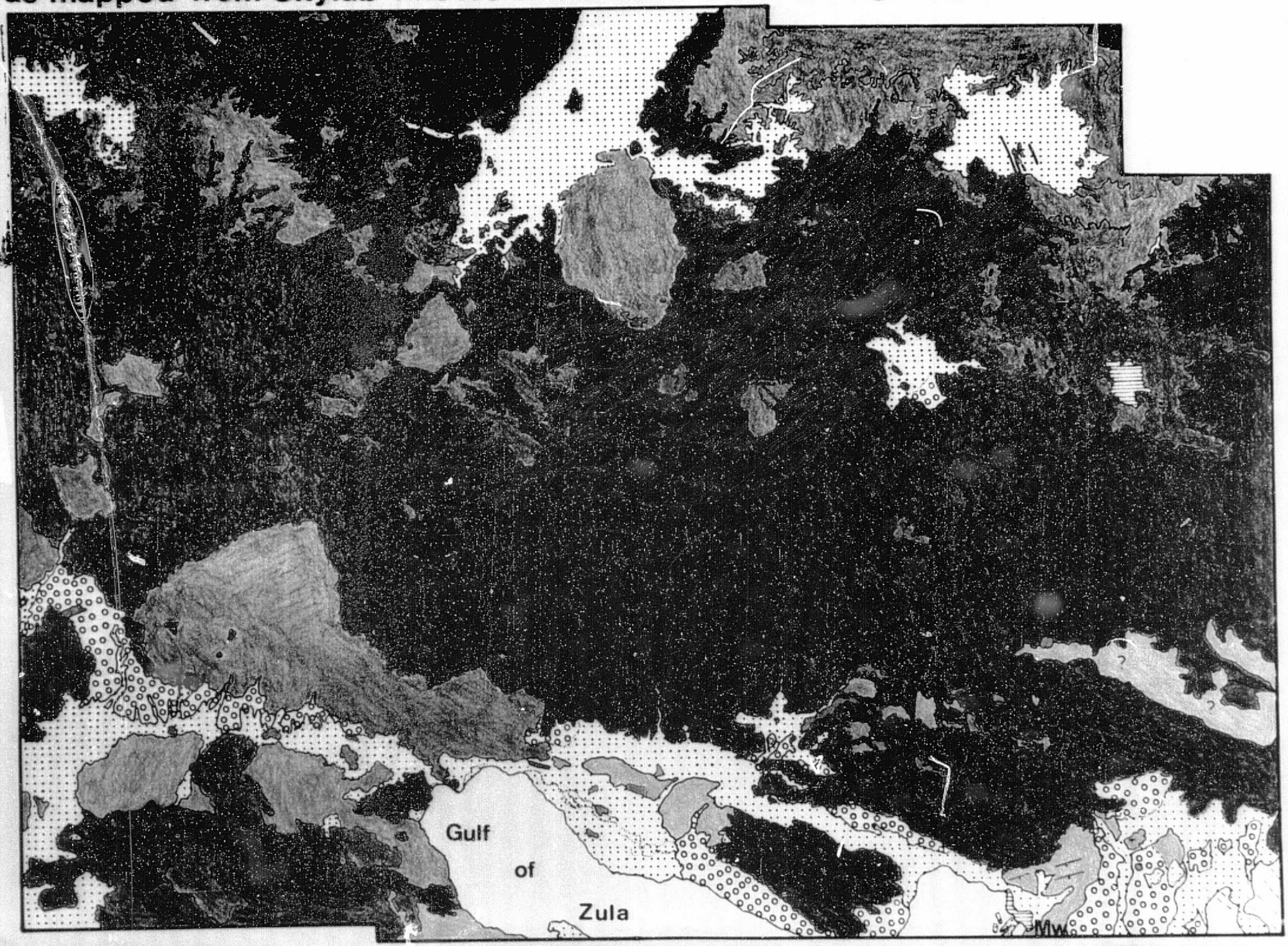
Where available, Skylab-photography should be used for map compilation in all projects of regional geological mapping, hydrogeological projects and water inventories, in mineral exploration and engineering geology.

Attached

Fig. 1 Map of Surface Drainage
Fig. 2 Litholcgical Map
Fig. 3 Map of Surface Structures

Lithological Map

as mapped from Skylab Photos of the Asmara (Asm) Region (Ethiopia)



L E G E N D (Lithological map)

EXTRUSIVES


Aden series, basaltic and intermediate volcanics (Pleistocene-Holocene)


Afar series, plateau forming volcanics, mainly basaltic (Pliocene-Pleistocene)


Acid extrusives, undifferentiated (Pliocene-Holocene)


Basaltic extrusives (Tertiary)


Dykes (Tertiary)


Trap series, basalts, rhyolites (Tertiary)

SEDIMENTARY ROCKS


Laterite around Asmara


Alluvial sand and gravels, old shore lines (Subrecent-Recent)


Sand dunes (Subrecent-Recent)


Sheet flood terraces (Pleistocene-Holocene)


Fresh water sediments (Holocene)


Clastics, evaporites and limestones, desert serie (Miocene-Pliocene)


Sandstone (Mesozoic)


Undifferentiated sediments (Mesozoic)


Peneplain (possibly with remenants of paleozoic sediments)

METAMORPHIC BASEMENT


Granitic intrusives (Precambrian)

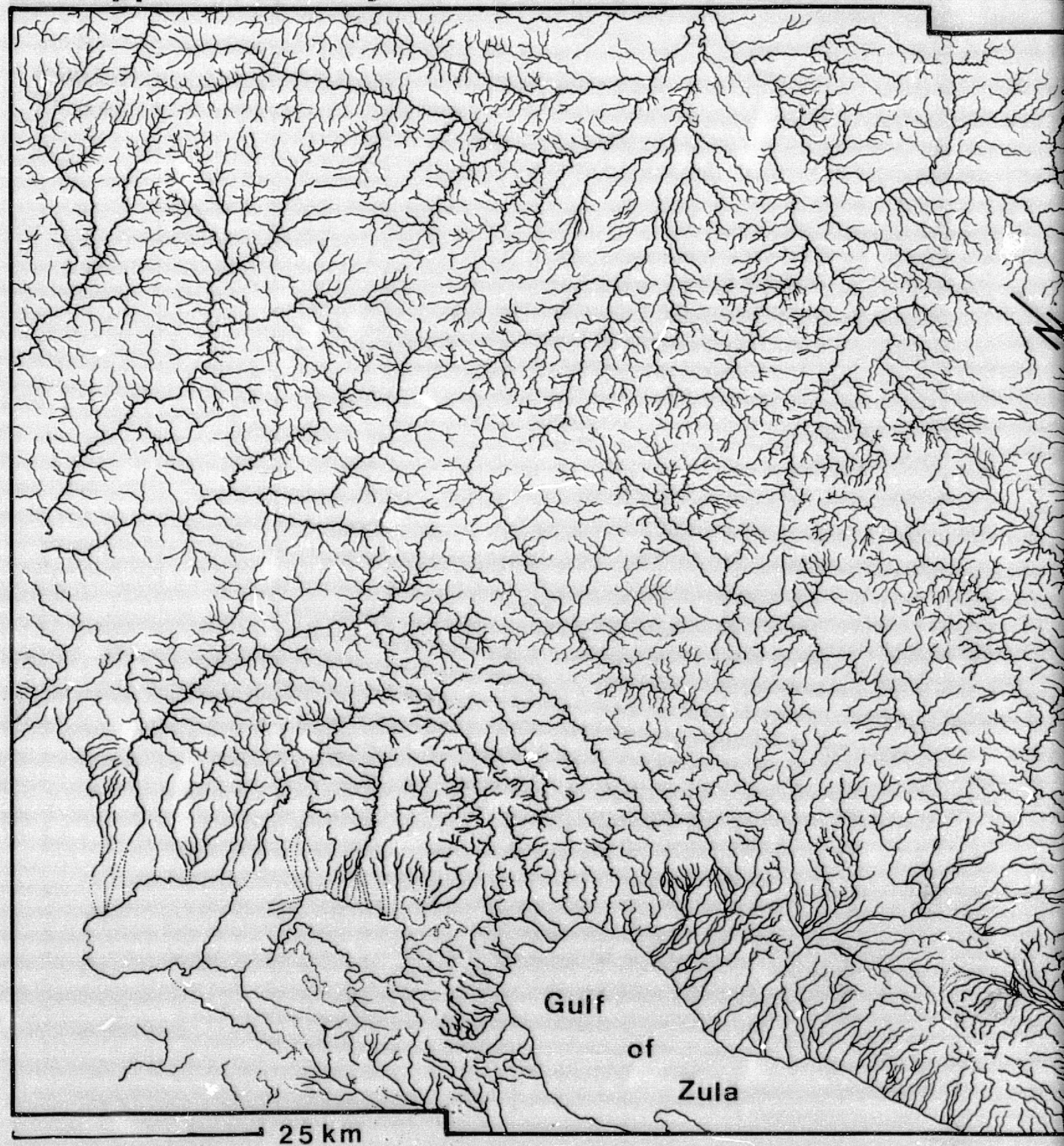

Phyllites, greenshists, graywackes, conglomerates (Precambrian)


Strike and dip

FOLDOUT FRAME

Surface Drainage

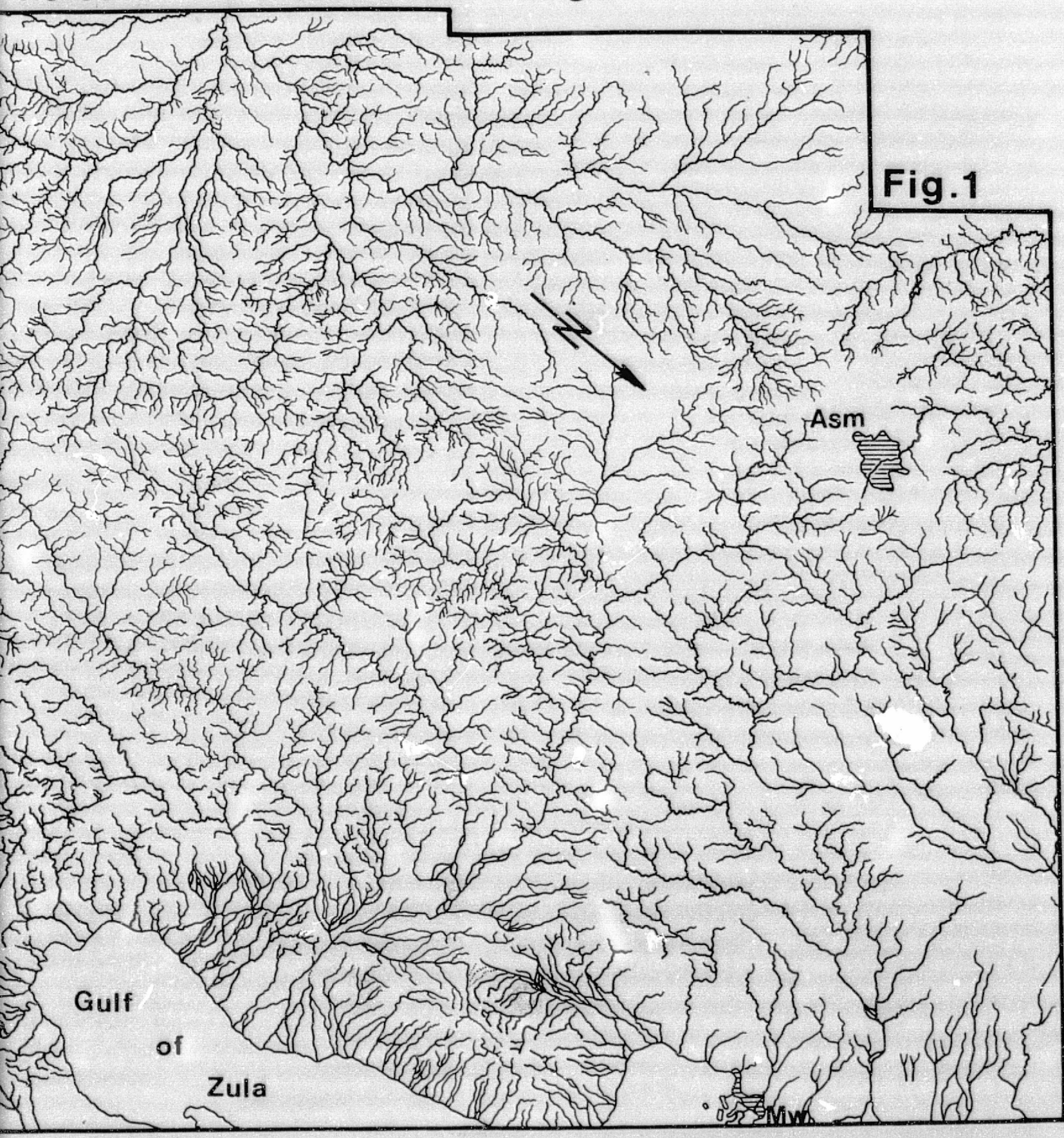
as mapped from Skylab Photos of the Asmara (Asm) Reg



Surface Drainage

FOLDOUT FRAME 2

Photos of the Asmara (Asm) Region (Ethiopia)



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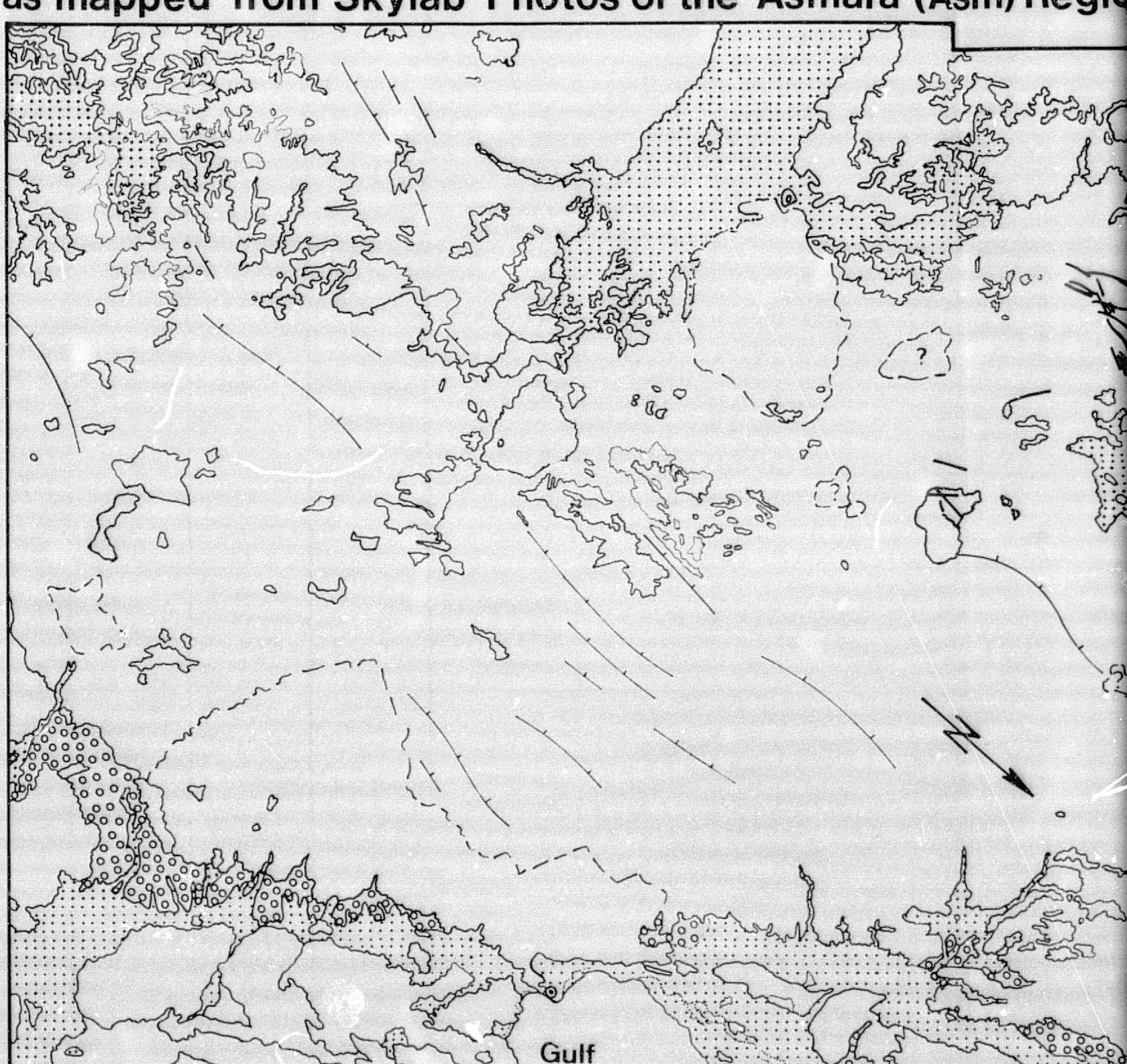
Lithological Map

as mapped from Skylab Photos of the Asmara (Asm) Regio



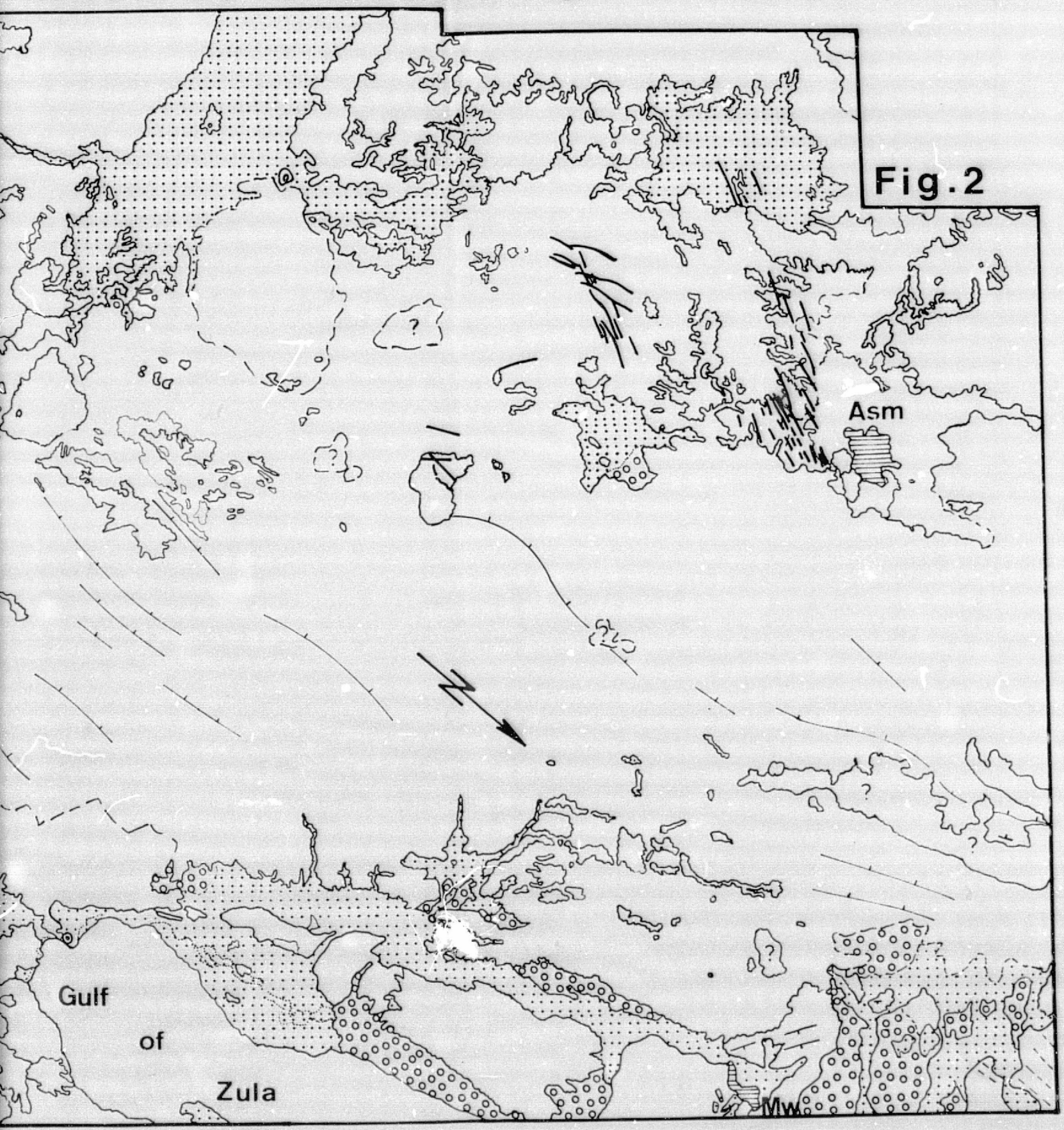
10 a

10 B

Lithological Map

FOLDOUT FRAME 2

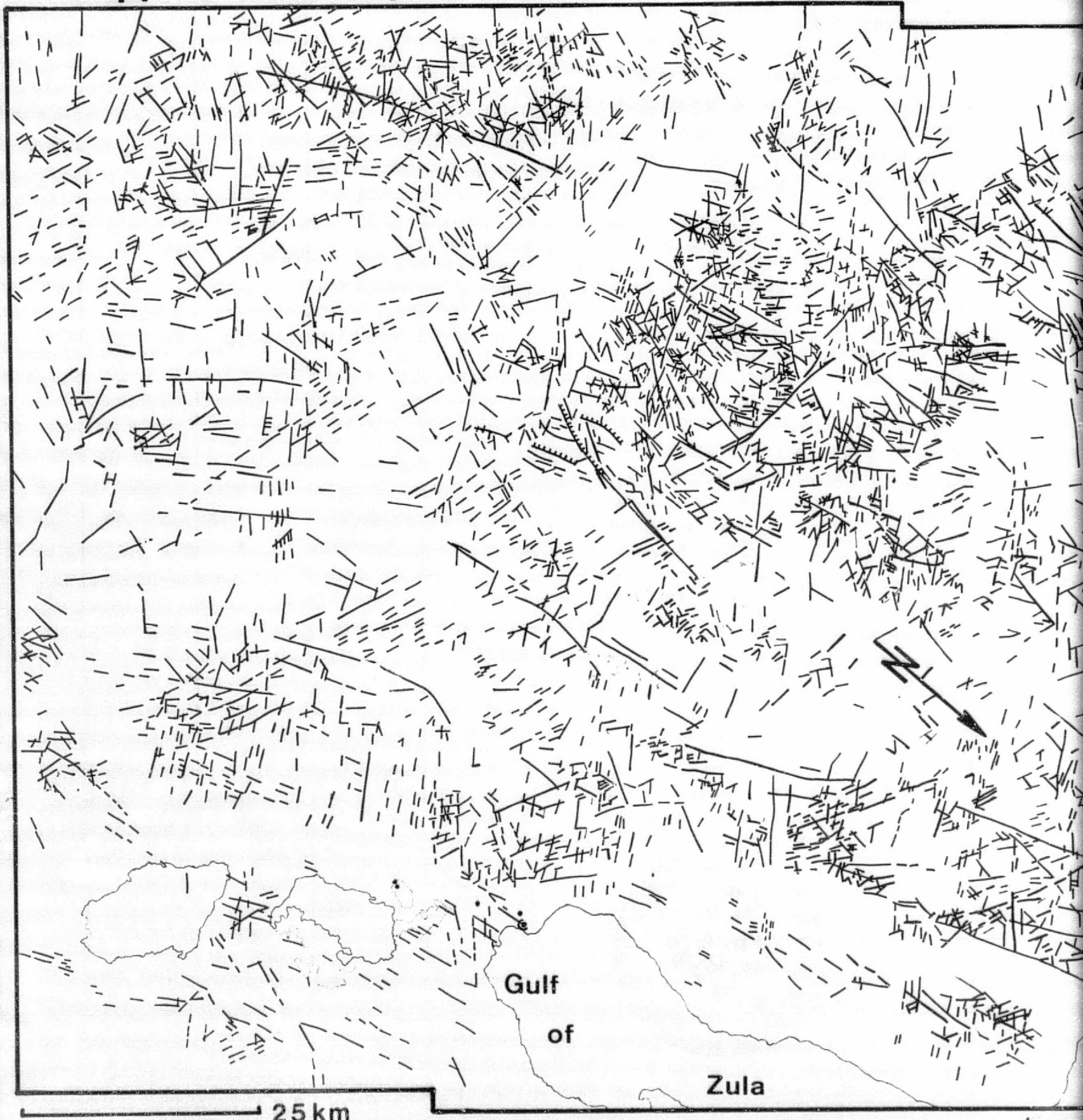
Photos of the Asmara (Asm) Region (Ethiopia)



FOLDOUT FRAME

Surface Structures

as mapped from Skylab Photos of the Asmara (Asm) Regi



11 A

11 B

Surface Structures

o Photos of the Asmara (Asm) Region (Ethiopia)