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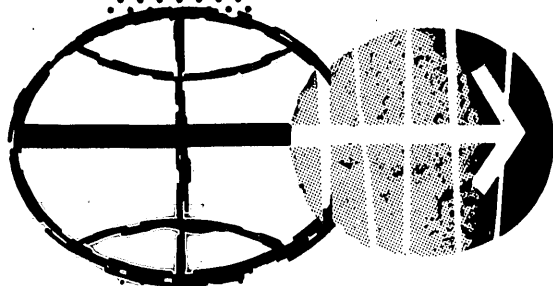
HYDROLOGIC EVALUATION OF GEMINI PHOTOGRAPHS
OF FRINGES OF THE SAHARA, AFRICA

By

J. R. Jones
U. S. Geological Survey
Washington, D. C.

April, 1967

Prepared by the Geological Survey for the
National Aeronautics and Space Administration (NASA)
under NASA Contract No. R-09-020-013



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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WASHINGTON, D.C. 20242

Technical Letter
NASA-68
May 1967

Dr. Peter C. Badgley
Program Chief,
Earth Resources Survey
Code SAR - NASA Headquarters
Washington, D. C. 20546

Dear Peter:

Transmitted herewith is one copy of:

TECHNICAL LETTER NASA-68
HYDROLOGIC EVALUATION OF GEMINI PHOTOGRAPHS
OF FRINGES OF THE SAHARA, AFRICA*

by

J. R. Jones**

April 1967

Sincerely yours,

William A. Fischer
Research Coordinator
Earth Orbiter Program

*Work performed under NASA Contract No. R-09-020-013
**U.S. Geological Survey, Washington, D. C.

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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

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not be quoted without permission

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Space Administration (NASA)

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HYDROLOGIC EVALUATION OF GEMINI PHOTOGRAPHS
OF FRINGES OF THE SAHARA, AFRICA

by J. R. Jones^{1/}

Abstract

Five Gemini color photographs, including one from Gemini IV, three from Gemini V, and one from Gemini IX, are evaluated for their content of information of hydrologic significance. Geographic, geomorphic, and geologic features are annotated on overlays. Outstanding features clearly displayed in the photos include the paleohydrologic (transitional) nature of the eastern shore of Lake Chad; topographic and color manifestations of geology near the Atlantic Coast of Morocco, and the hydrologic control on location of towns in that region (37 towns were located in one photograph); the sharp contrast between the water-rich Nile Delta and adjacent desert; the disappearance of the Jabal Nafūsh escarpment in Libya; and the intricate drainage patterns of the flat-lying beds which form the Jabal Nafūsh.

Introduction

Color photographs taken by Gemini astronauts are of hydrologic interest because they provide views of unprecedented synoptic content and quality. Geographic, geomorphic, and geologic features revealed in the photographs, as well as obvious water bodies such as lakes and streams, are important for hydrologic interpretation.

Five selected Gemini photographs of the fringes of the Sahara in North Africa are evaluated in this report for their hydrologic significance (figure 1). The author is personally familiar with the areas shown in the five photographs. This evaluation is part of a program wherein scientists evaluate empirically the data from various airborne and spaceborne remote sensors.

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Visible-light photographic cameras have been and are expected to continue to be the sensors most useful to hydrologists.

Each photograph has been reproduced with an accompanying overlay indicating the features detected. Photograph 54-63 (fig. 6a) has two separate overlays, one for geology and one for geography.

The photographs were all taken with a hand-held, modified Hasselblad camera, Model 500, equipped with an 80mm Zeiss Planar f.28 lens. The film used was General Aniline Anscochrome for photo 54-63, and Kodak Ektachrome for the other photos. Other pertinent information about the photographs is tabulated below:

<u>Photo No.</u>	<u>Gemini Mission</u>	<u>Orbit</u>	<u>Date</u>	<u>Time</u>	<u>Astronauts</u>
51-4	V	14	8/22/65	1106	Cooper, Conrad
52-17	V	87	8/27/65	0658	Cooper, Conrad
472-1	IV	12	6/4/65	0910	McDivitt, White
9B-50	IX	44	6/6/66	1123	Stafford, Cernan
54-63	V	74	8/26/65	1025	Cooper, Conrad

The altitudes from which the photographs were taken are within the range, 86-215 nautical miles. The perigee (lowest point in the orbit) and apogee (highest point) for Gemini missions IV, V, and IX were, respectively, 100-175, 100-215, and 86-144 nautical miles.

Photograph 51-4, Mediterranean Coast, Tunisia and Libya

The photograph (figs. 2a, 2b) illustrates a rather dry landscape, stretching more than 500 air miles. Distance, distortion, and cloud cover detract from its utility. It depicts the disappearance of the Jabal Nafūṣah escarpment in Tunisia.

Photograph 52-17, Coastal Plain, Northwestern Libya

Features of hydrologic significance may be seen (figs. 3a, 3b). The area receives sufficient precipitation to support native scrub vegetation and grass, and is considered to be outside the Sahara proper. Large cultivated areas are readily discernible, and some types of vegetation in groves show up somewhat differently. Palm groves in particular show clearly; the irrigated "Arab gardens" in conjunction with many palm groves, such as those east of Tripoli, may accentuate their color. Areas of active sand dunes also are readily distinguishable. Towns are surprisingly difficult to spot, especially in contrast with the Italian farms (most now occupied by Libyans), many of which were laid out as colonization projects. The nearly flat-lying beds which form the Jabal Nafūṣah escarpment present a clear pattern of stream erosion. The probability of faulting rather than marine erosion as the cause of the scarp is suggested by the smooth curve of the base of the scarp near the right margin of the photo.

Interpretation of hydrologic conditions must depend in part on surmise and knowledge of local conditions. The sabkhahs (salt flats) indicate high evaporation rates coupled with rather low precipitation

(except right at Tripoli less than 16 inches per year). Only in the right half of the photo, from Wādī al Majānīn eastward, do floods of the normally dry streams cross the plain (Gefara) to the sea. Most runoff from the bare, steep hills percolates to ground-water reservoirs or evaporates. The farm areas, especially the "Arab gardens" near the coast, indicate that ground water is available for irrigation. The "Arab gardens" are traditionally watered by animal power, therefore lifts must be low. Most of the olive groves in the Gefara were irrigated for at least their first two seasons and the citrus must be irrigated with water of rather good chemical quality.

Photograph 472-1, Nile Delta and Great Rift

This photo (figs. 4a, 4b) clearly illustrates the importance of water -- in this area supplied by the Nile -- which makes the delta a bast garden that contrasts sharply with the adjacent desert. Evaporation has concentrated salts in the "sabkhahs," the Dead Sea, and formerly, Great Bitter Lake. The depression Wādī al Natrūn at the right margin of the picture supports vegetation watered, probably in part irrigated, by shallow ground water.

Photograph 9B-50, Lake Chad, Chad, Niger, and Nigeria

Paleohydrologic features may be seen (figs. 5a, 5b). The photograph shows clearly the remarkable transitional nature of the eastern shore of Lake Chad; it is almost impossible to determine a shoreline. Because of the low gradient of the bottom of the shallow lake and of the land adjacent on the east and north, a small change in lake level causes

a relatively large movement of the shoreline. Because the land surface consists of sand dunes of differing heights and configuration, there is a gradual zonal change from land, to land with ponds, to land with bays, to bays with peninsulas and islands, to islands, to open lake.

Linear features in the northwestern part of the photo probably represent shorelines formed at maximum or near-maximum stages of the lake, presumably in the Pleistocene Epoch. Although the western shore of the lake changes position but slightly when lake stage is in the modern range, the northern and eastern shores at various stages are subparallel to each other. Thus the shape of the lake remains relatively constant, based on the west shore, but the area varies greatly. Additional evidence of formerly higher water levels is provided by the former lagoon south of the Komadugu Yobe.

The westward limit of the area of submerged dunes shows the diminished extent of the lake during one or more past dry periods. The outlines of the dunes have persisted despite wave action.

The general orientation of dunes is approximately northwest-southeast. A lineation nearly at right angles to this is apparent in the submerged dune area, especially in the northern part of the lake, and inland to the east of the lake. The dark patches which mark the lineations may be either patches of vegetation or open water, indicating the proximity of the water table to land surface. In recent years, the lake has been exceptionally high.

The white areas northwest of the lake are probably active sand dunes. The white color of the dunes may indicate that diatomite,

reported to occur in the general area, constitutes an appreciable part of the dune sediments.

Photograph 54-63, Atlantic Coast, Ifni, and Morocco

Topographic and color manifestations of geologic units are strikingly displayed in this photo (figs. 6a, 6b). Although there is marked similarity between the ASGA-UNESCO Geological Map of Africa, Sheet 1, and relief shown on the photo, it was not possible to relate all mapped units to the photo. Three ages of Precambrian rocks are distinguished on the geologic map and at places on the photo, but descriptions of lithology are so generalized in literature and geologic maps that at most places no attempt was made to differentiate on the photo between the three Precambrian units.

Even the most conspicuous water courses in this region of low precipitation are usually dry most of each year. A number of towns are discernible (fig 6a) because they are in areas of irrigated cultivation. On the overlay (fig. 6c) towns are identified by numbers keyed to the list below. Most towns are sited on Quaternary deposits, the only rocks which at most places yield water sufficiently freely for use in irrigation.

List of towns indicated on Gemini Photo 54-63

- | | |
|-------------------------|---------------------------|
| 1. Assaka | 20. Targhjicht |
| 2. Agadir | 21. Anamer |
| 3. Tracim | 22. Sidi Ifni |
| 4. Iksabi | 23. El Argoub |
| 5. Duaroun | 24. Name not shown on map |
| 6. Sidi Athmane | 25. Ait Moussa |
| 7. Goulimine | 26. Name not shown on map |
| 8. Asrir | 27. El Kseib |
| 9. Ait Boukha | 28. El Aouina |
| 10. Taourirt Doubiane | 29. N'Salah Bammou |
| 11. Fask | 30. Idehr |
| 12. Tiflit | 31. Oujiane |
| 13. Ait-Moussa-ou-Daoud | 32. Tiznit |
| 14. Abeino | 33. Name not shown on map |
| 15. Sidi Messaoud | 34. Name not shown on map |
| 16. Ouaoutelt | 35. Attebane |
| 17. Tagant | 36. Timsilil |
| 18. Bou Izakarene | 37. Ahl Mader |
| 19. Tagmout | |

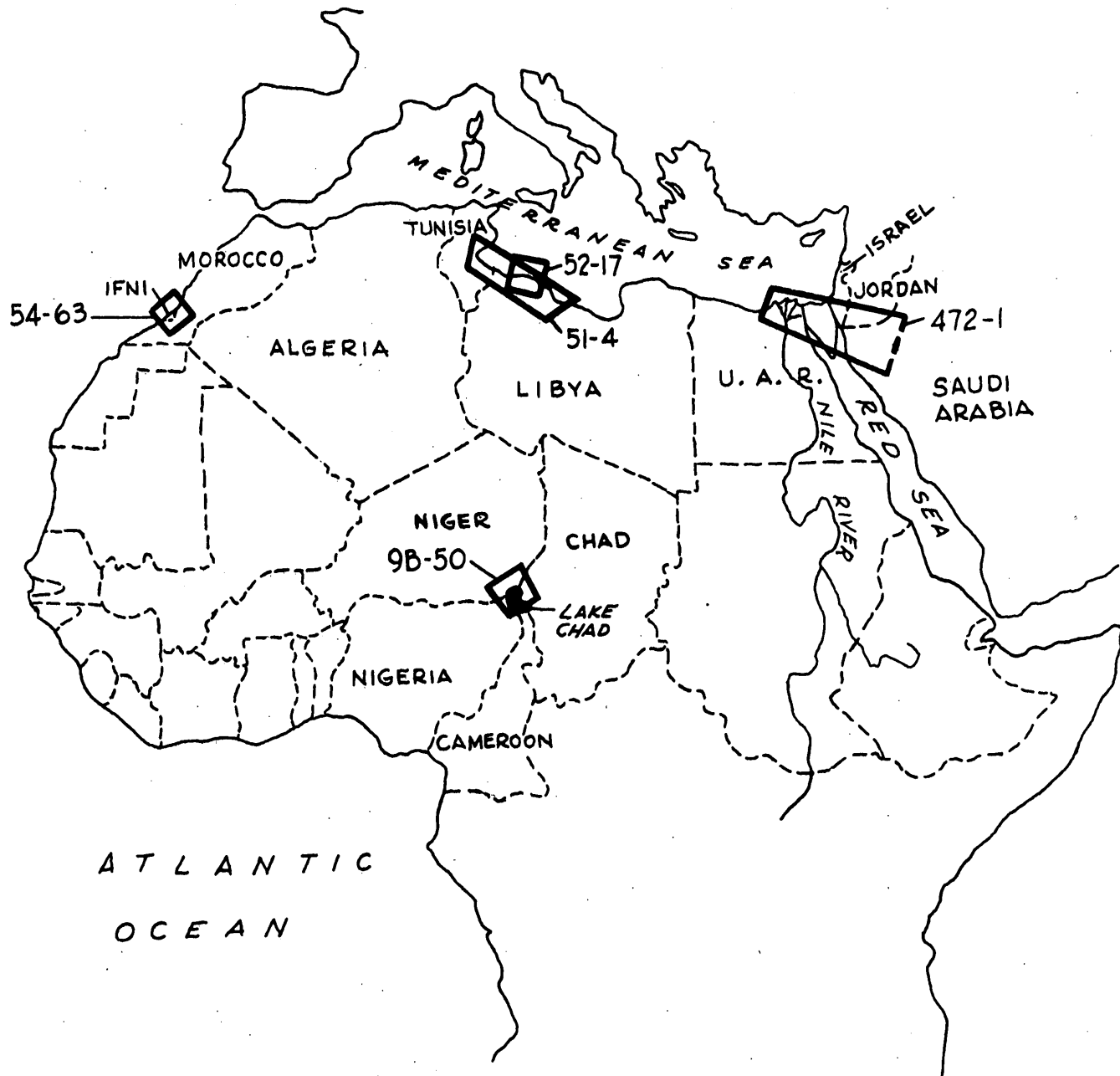
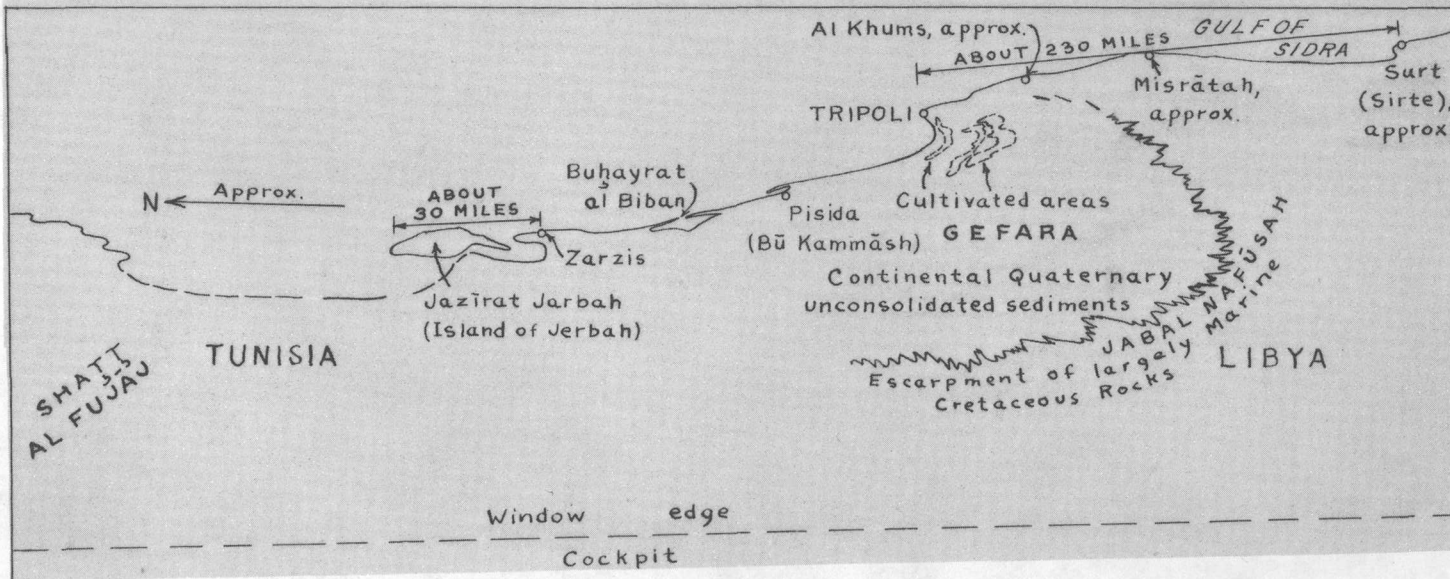


Figure 1. -- Location map.



Fig. 2a



NASA—Gemini photo 51-4

Annotation by U.S. Geological Survey,
September 1966

Fig. 2b

MEDITERRANEAN COAST, TUNISIA AND LIBYA

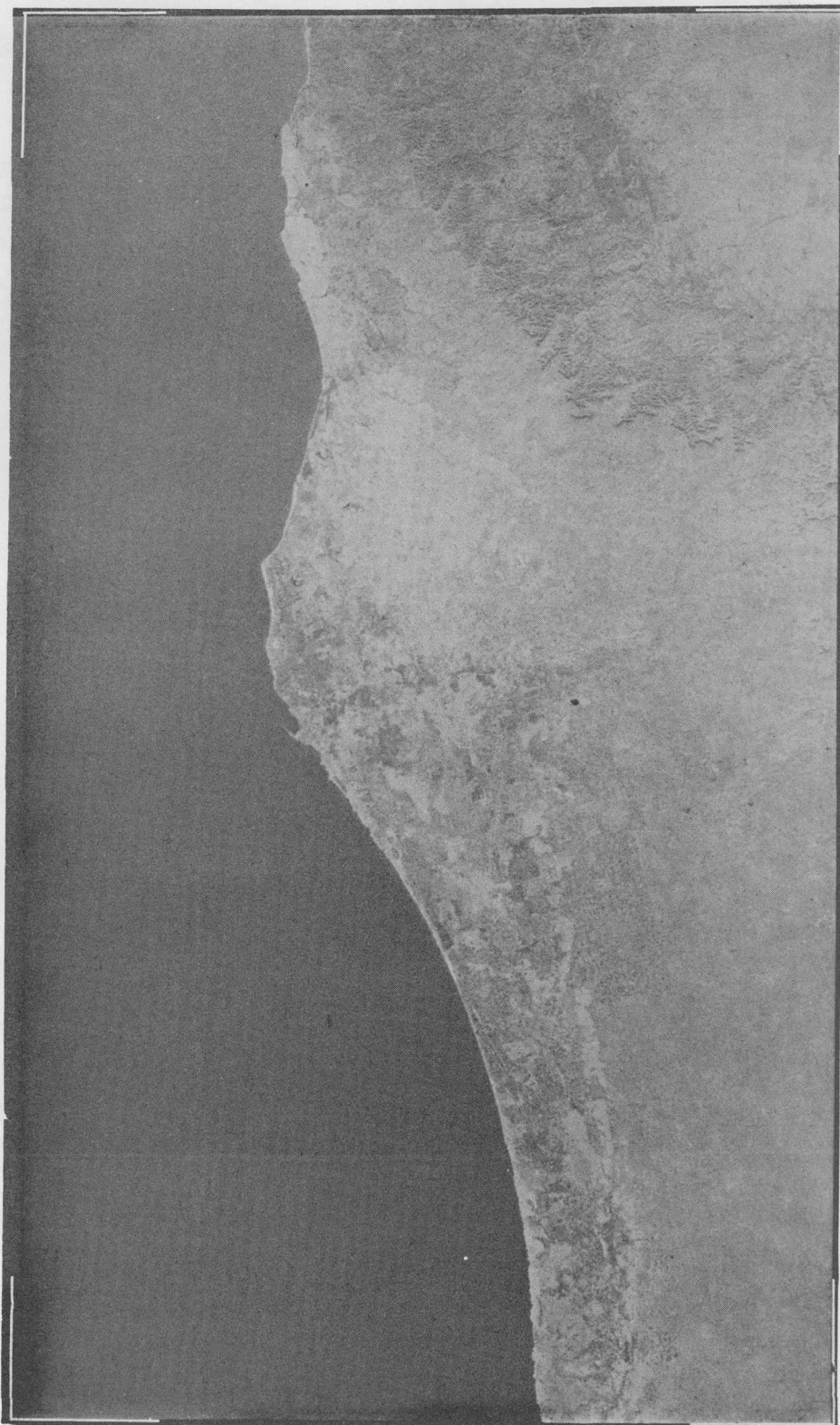


Fig. 3a

NASA-Gemini photo 52-17

COASTAL PLAIN, NORTHWESTERN LIBYA

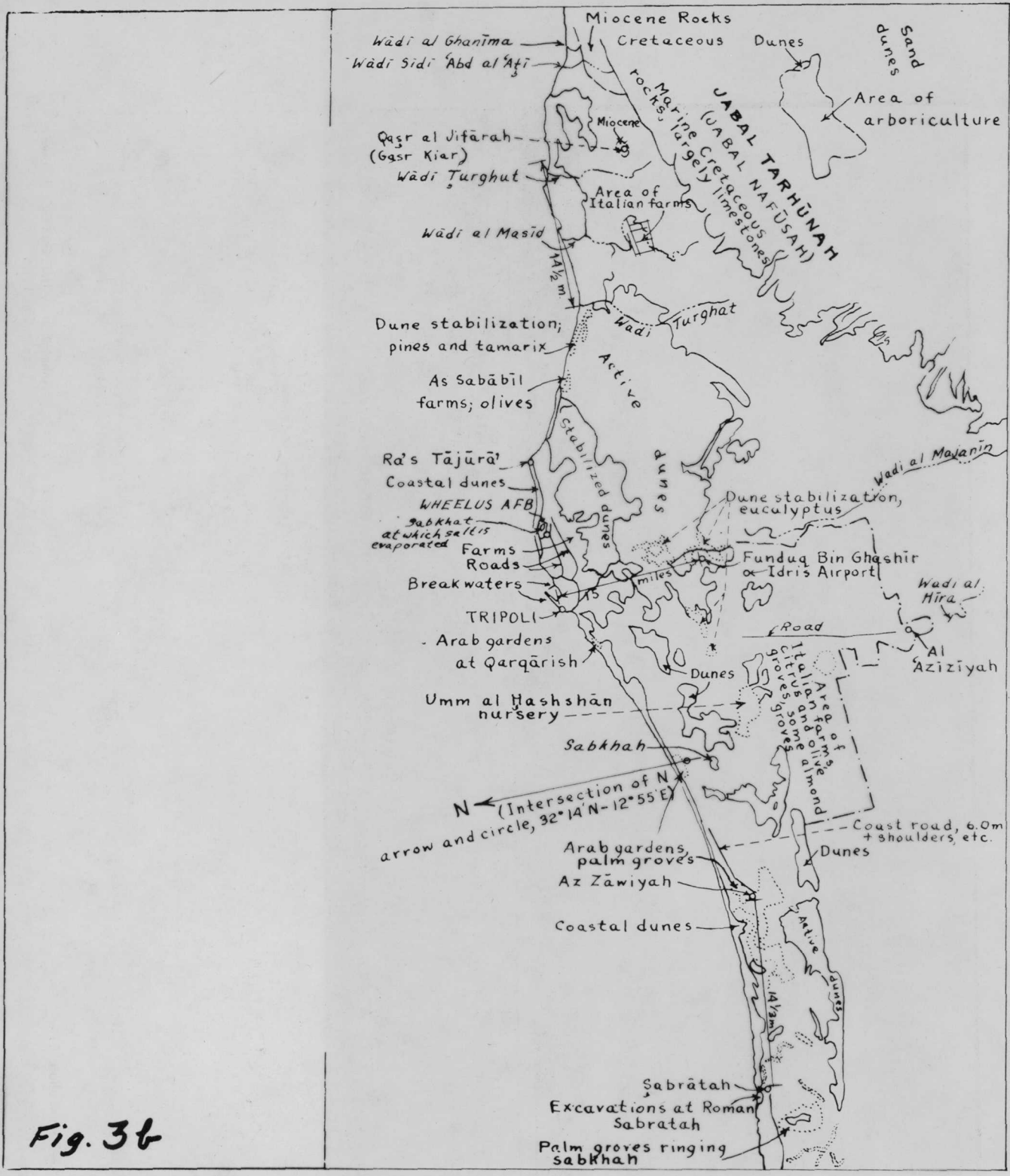


Fig. 36

ANNOTATION BY U.S. GEOLOGICAL SURVEY
 SEPTEMBER, 1966



Fig. 4a

NASA-Gemini photo 472-1

NILE DELTA AND GREAT RIFT

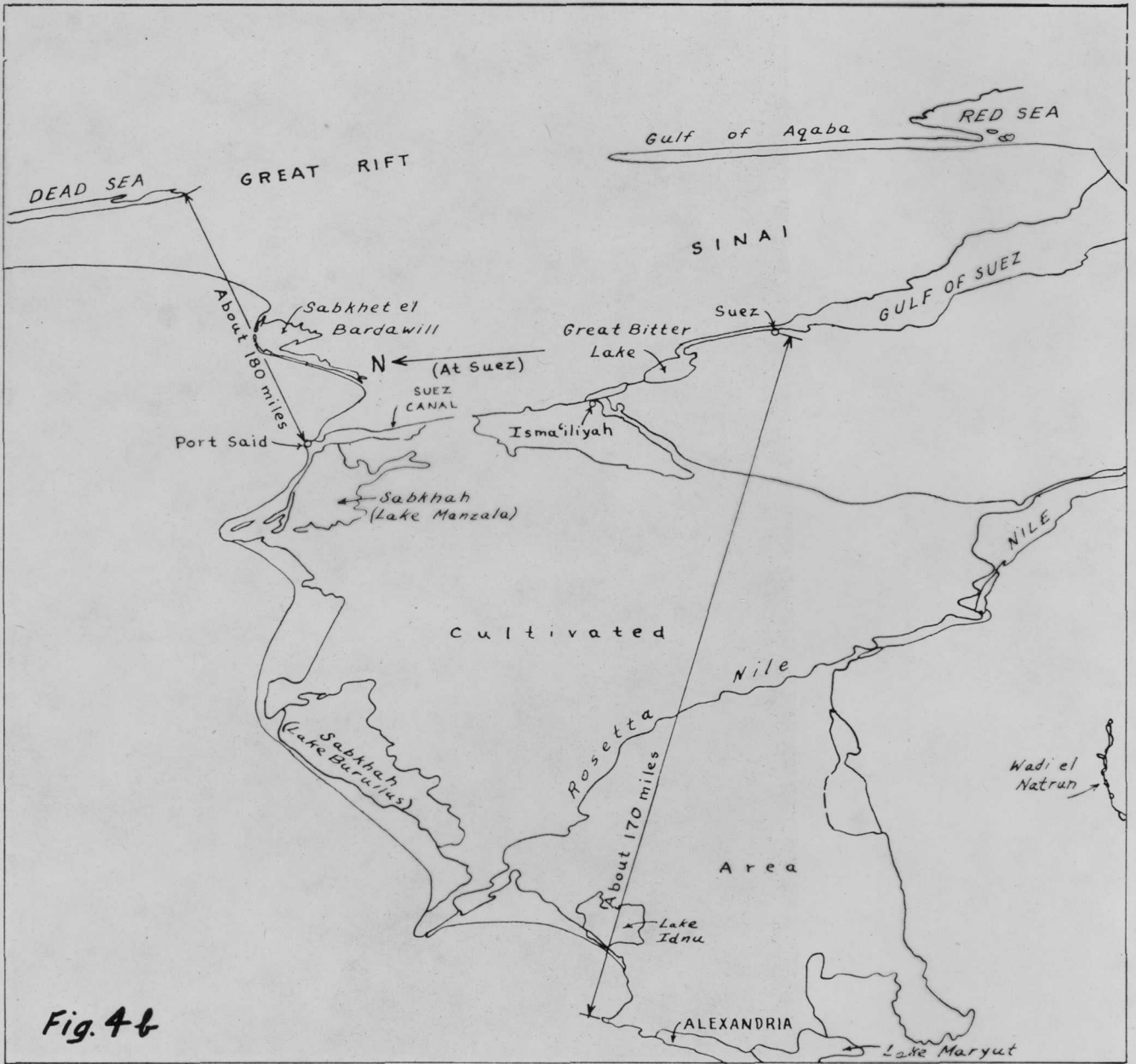
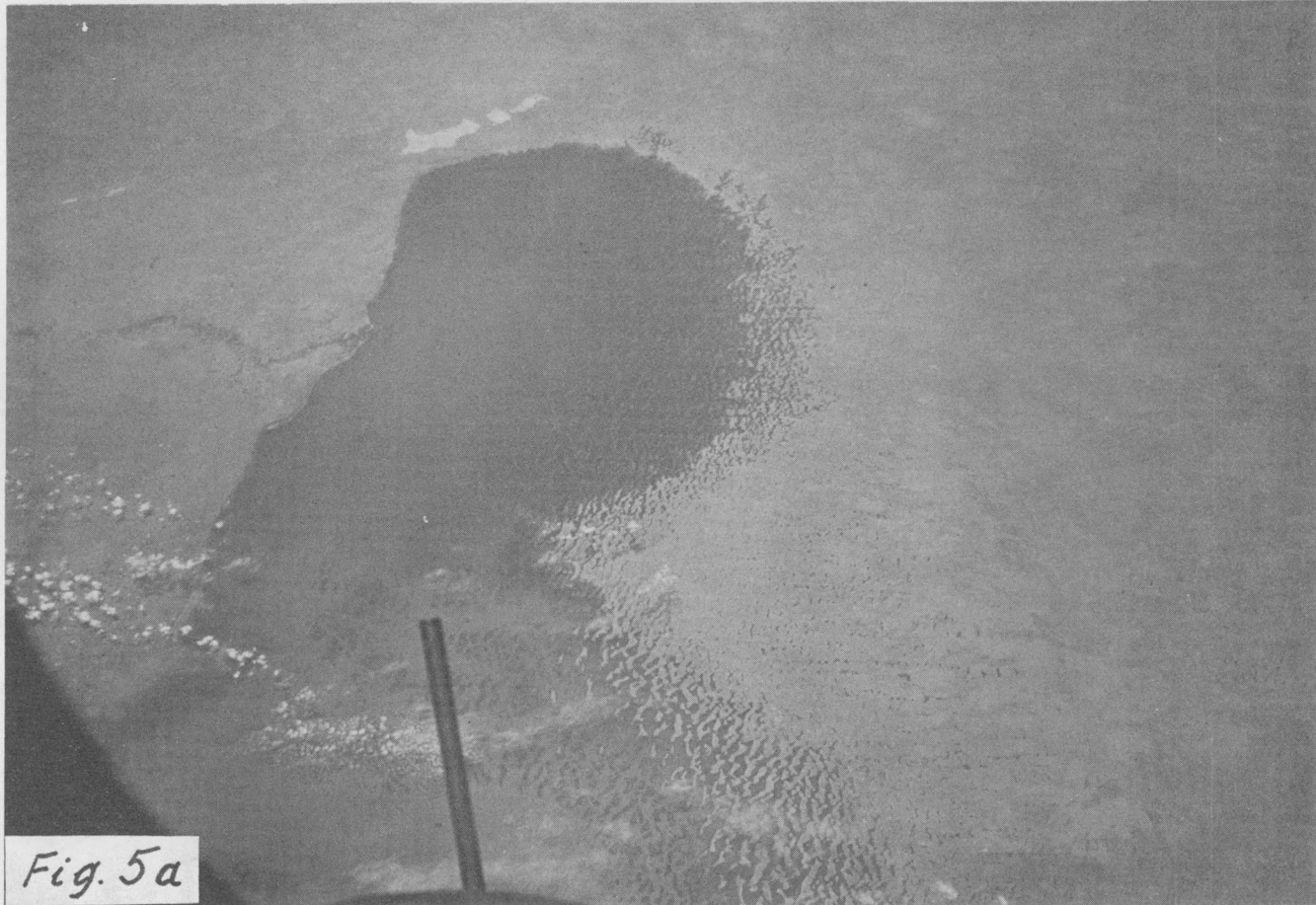


Fig. 4b

Annotation by U.S. Geological Survey,
September 1966



NASA-Gemini photo 9B-50

LAKE CHAD, CHAD, NIGER, AND NIGERIA

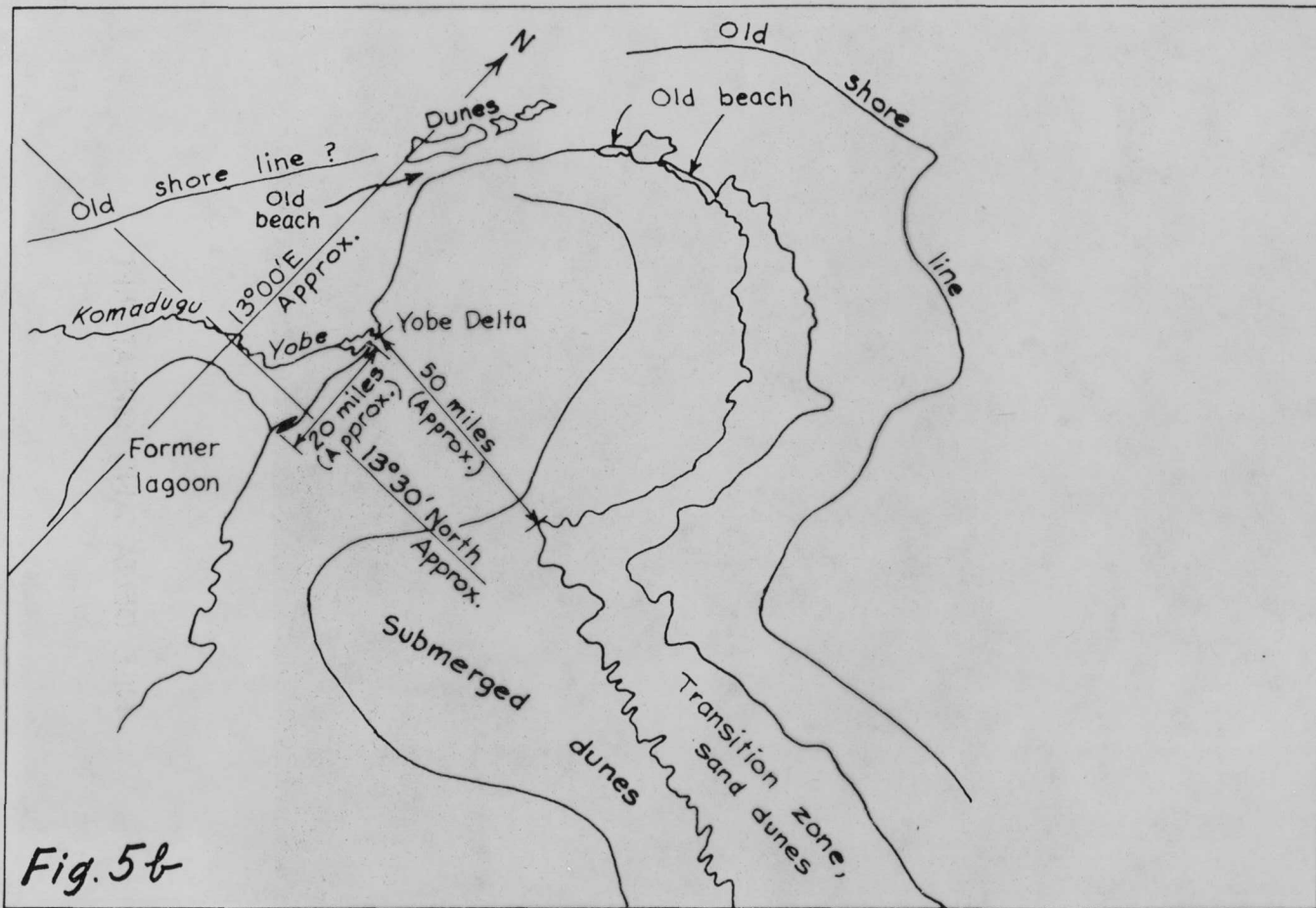


Fig. 5b

ANNOTATION BY U.S. GEOLOGICAL SURVEY
 SEPTEMBER 1966



NASA-Gemini photo 54-63

ATLANTIC COAST, IFNI AND MOROCCO

Designation of rock ages
 Q, Quaternary
 C, Carboniferous
 EO, Cambro-Ordovician
 E, Cambrian
 pE, Precambrian
 (pE a, b, c; subdivisions
 of Precambrian in order
 of increasing age)

Abbreviations
 Cgl, conglomerate
 gr, granite
 ls, limestone
 "Schiste" is a French term
 including schist, slate
 and shale.

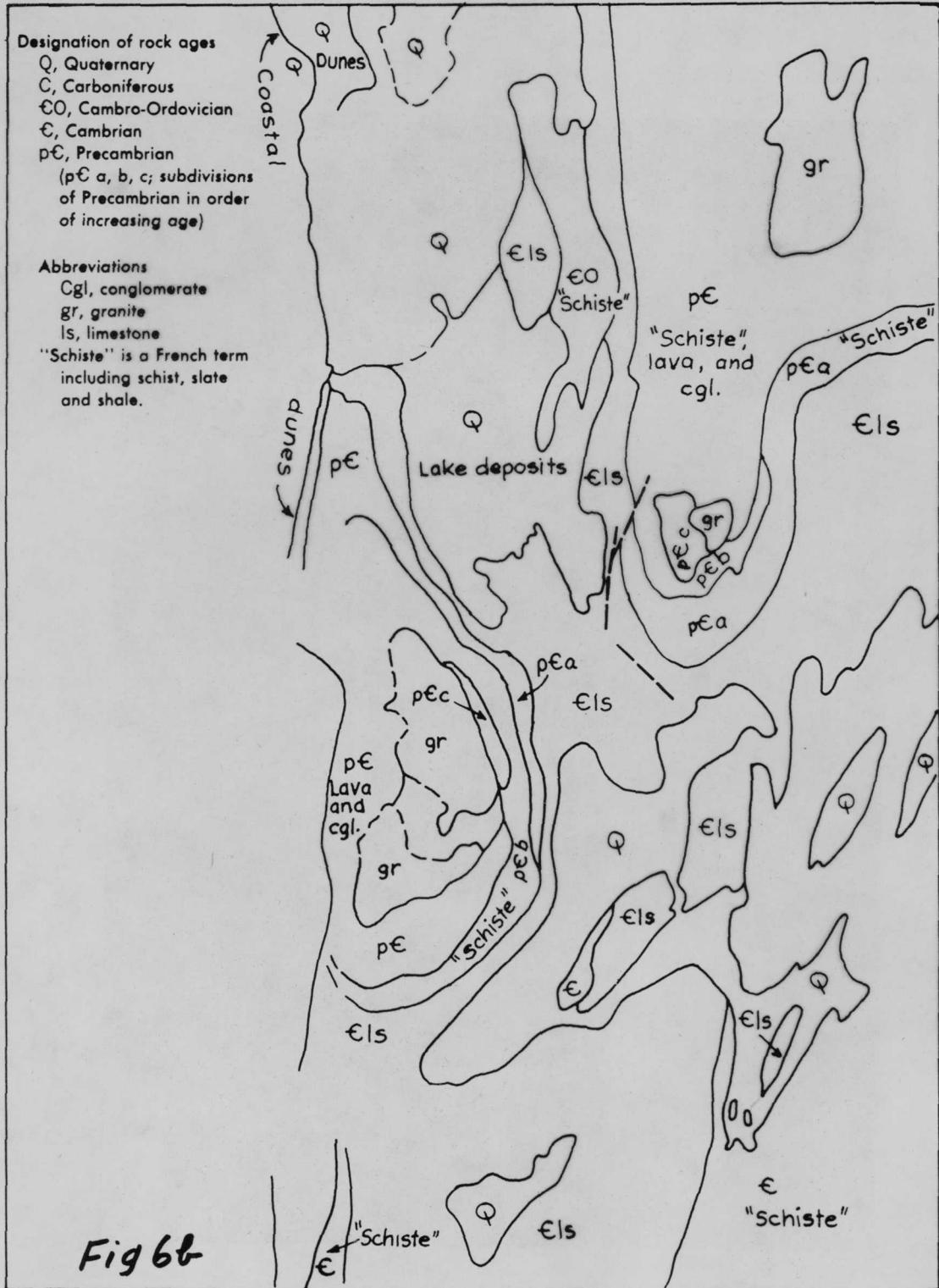
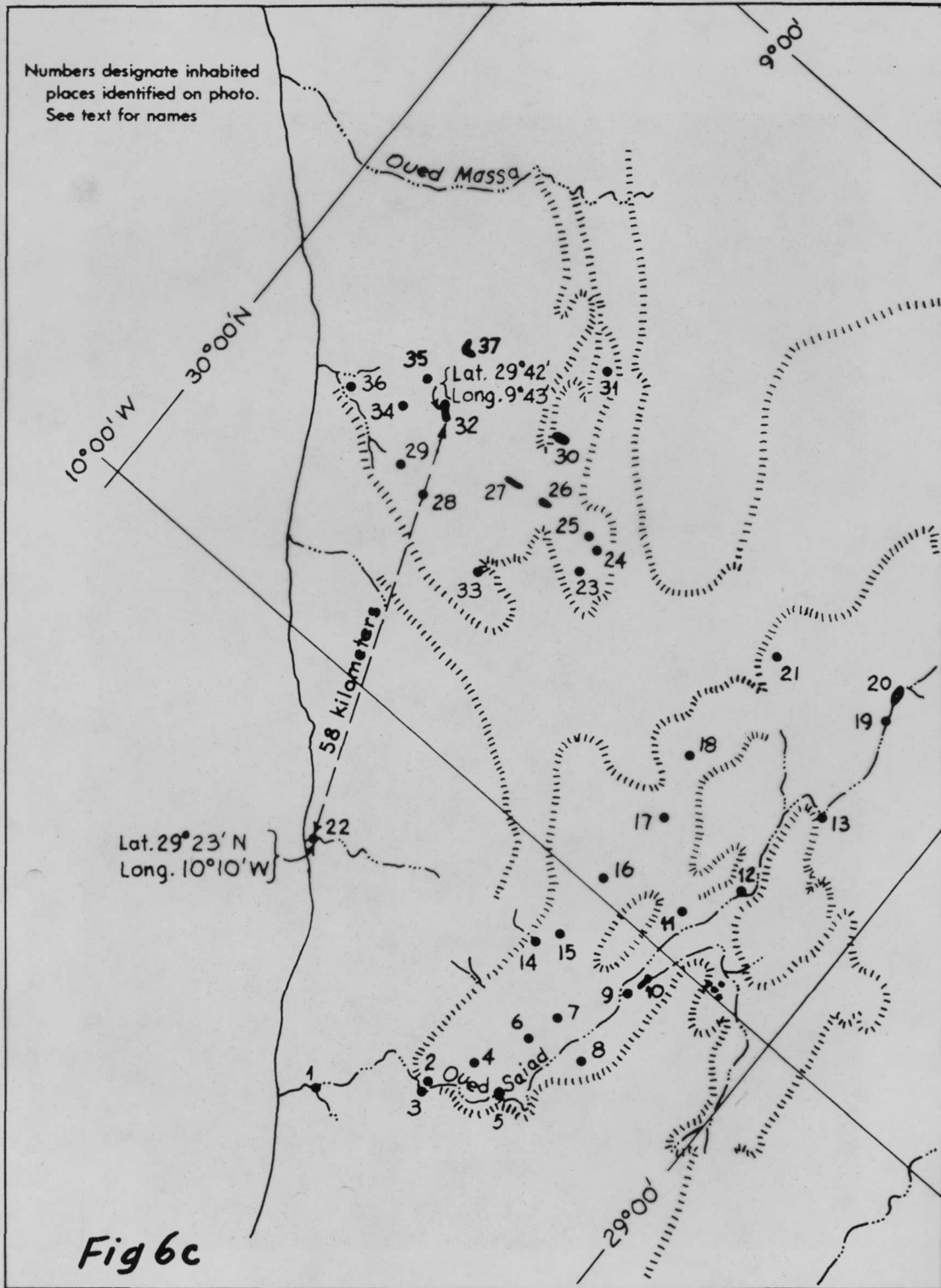


Fig 66

ANNOTATION BY U.S. GEOLOGICAL SURVEY
 SEPTEMBER, 1966



ANNOTATION BY U.S. GEOLOGICAL SURVEY
SEPTEMBER, 1966