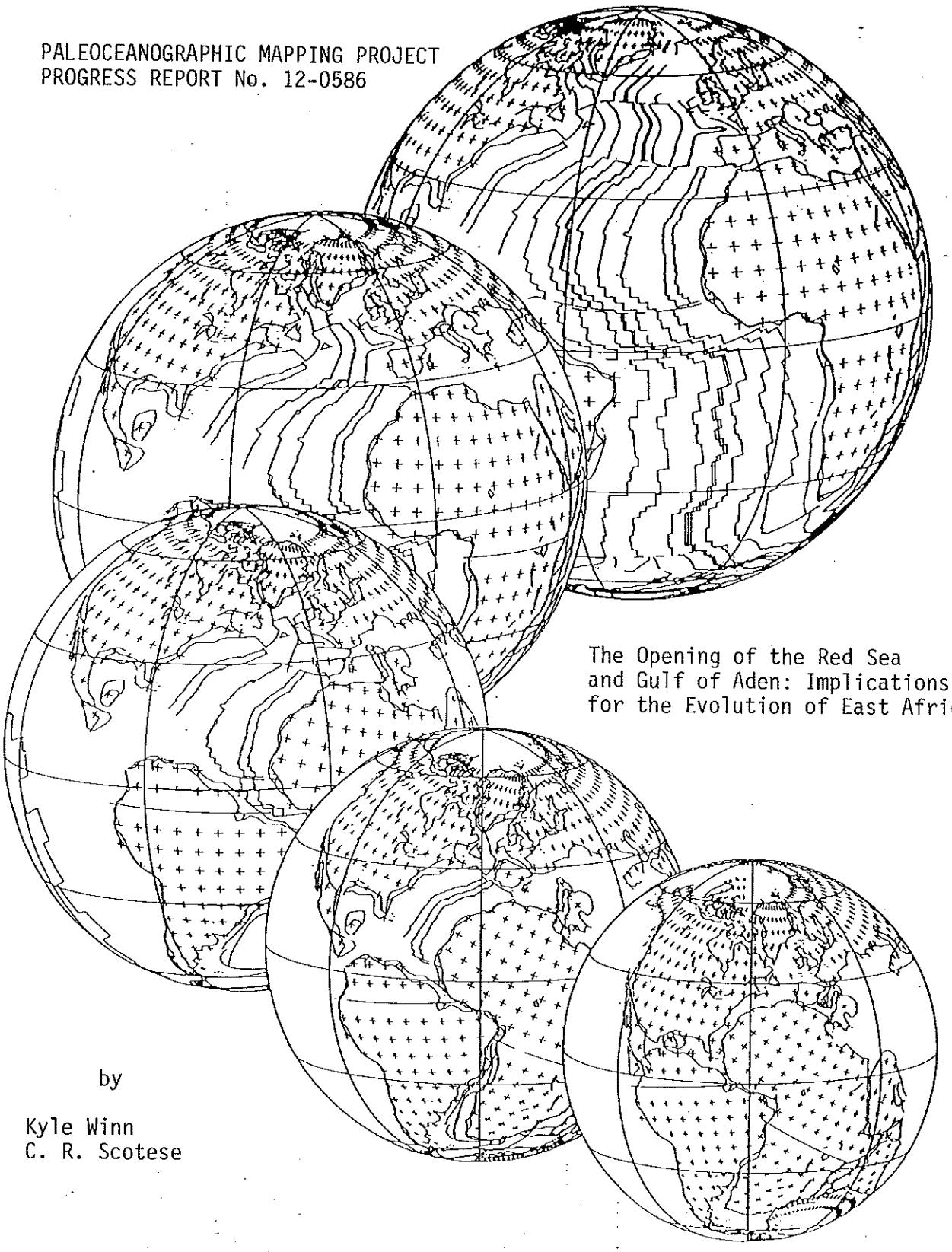
PALEOCEANOGRAPHIC MAPPING PROJECT
PROGRESS REPORT No. 12-0586



The Opening of the Red Sea and Gulf of Aden: Implications for the Evolution of East Africa

by

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Introduction

Reconstructions of the opening of the Red Sea and the Gulf of Aden are presented (Figures 1-5) illustrating the relative positions of Arabia, Somalia, and eastern Africa after complete closure of the Red Sea and Gulf of Aden, and at Chron 5 (10.6 Ma), Chron 3 (4.8 Ma), and Chron 2 (1.9 Ma) times. These maps are based on the published work of Cochran (1981, 1983), Coleman (1984), Courtillot et al. (1980), Girdler (1985), LePichon and Francheteau (1978), and McKenzie and Davies (1970). The closure of the Red Sea and Gulf of Aden is a particularly interesting problem as it relates to the evolution of the East African Rift System.

Closure of the Red Sea and Gulf of Aden

The best constraints for the fit of Arabia, Somalia, and East Africa are across the Gulf of Aden. In the Gulf of Aden the continent-ocean boundary is well defined, numerous fracture zones provide flow lines that can be used to match the rifted margins, and the morphological and geological fit across the Gulf is tightly constrained. In contrast, the fit of Arabia and East Africa across the Red Sea is less clear. The continent-ocean boundary in the Red Sea is not well defined due to the fact that the continental crust has been extensively stretched and intruded by basaltic dikes.

In reconstruction illustrated in Figure 1, we have matched the continent-ocean boundary on either side of the Gulf of Aden, and have closed the Red Sea coast-to-coast. This fit results in approximately 40 km of closure across the northern extension of the Gregory Rift System in Ethiopia. Interestingly, significantly less stretching (< 20 km) is required in the central and southern parts of the rift system.

Chron 5 (10.6 Ma) - Recent

Though the uplift and stretching in the Red Sea and Gulf of Aden regions probably dates back to the Early Oligocene, the active phase of rifting did not begin until the late Oligocene-early Miocene (25 Ma). By the Middle Miocene (10.6 Ma), oceanic crust with well-defined magnetic lineations had formed both in the Gulf of Aden and Red Sea (Figure 2). Sea floor spreading continued through the Late Miocene and Early Pliocene. At about Chron 3 time (4.8 Ma), rifting stopped in the Straits of Suez, and continued movement between Arabia and Africa was taken up by transform motion along the Dead Sea /Gulf of Aqaba Fault Zone. Approximately 2 million years ago, the volcanic land bridge across the Afar region was breached, and waters from the Red Sea and Gulf of Aden intermingled for the first time.

chron 5
10.6

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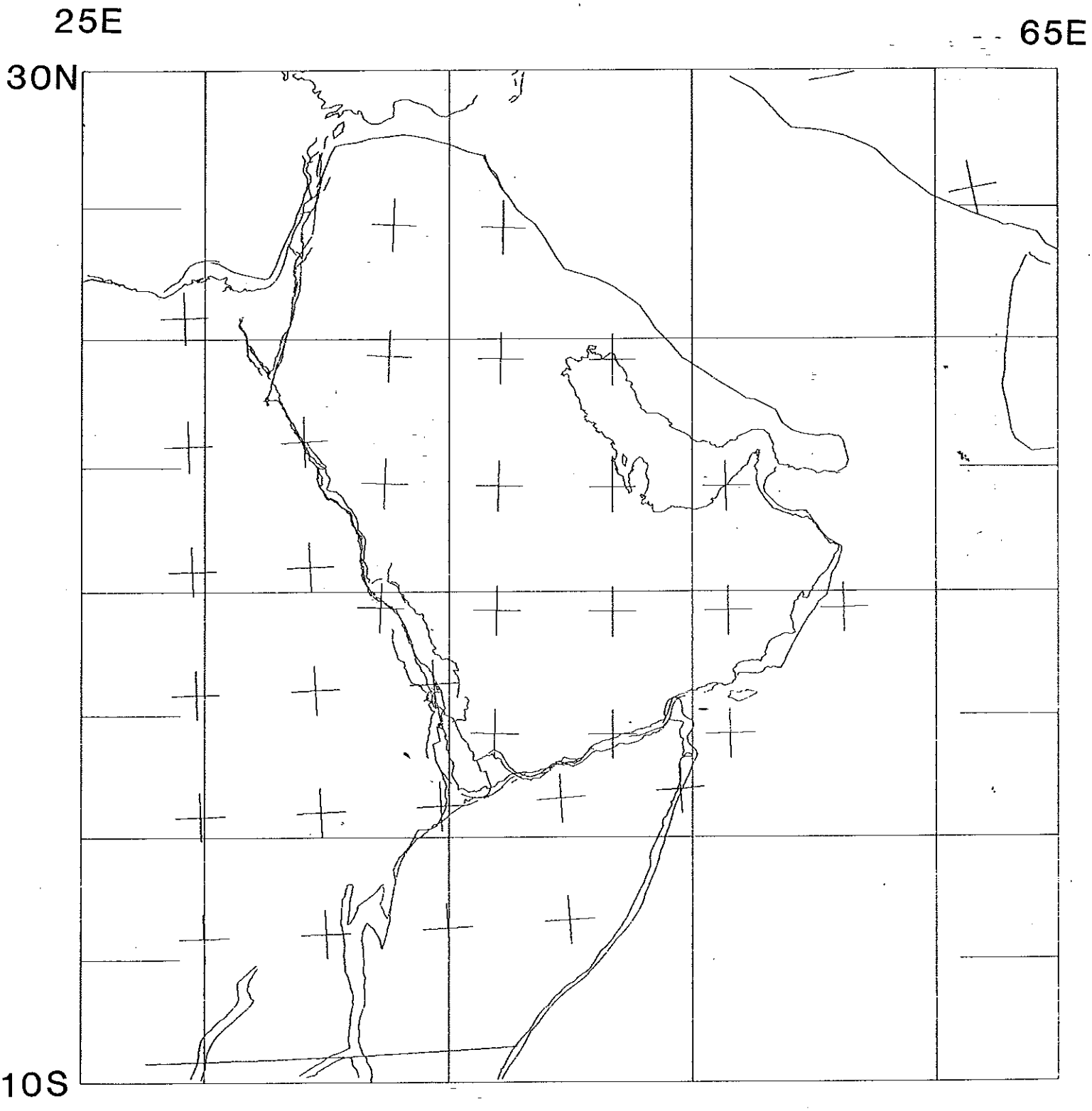

FIGURE 1. Fit (Early Oligocene)

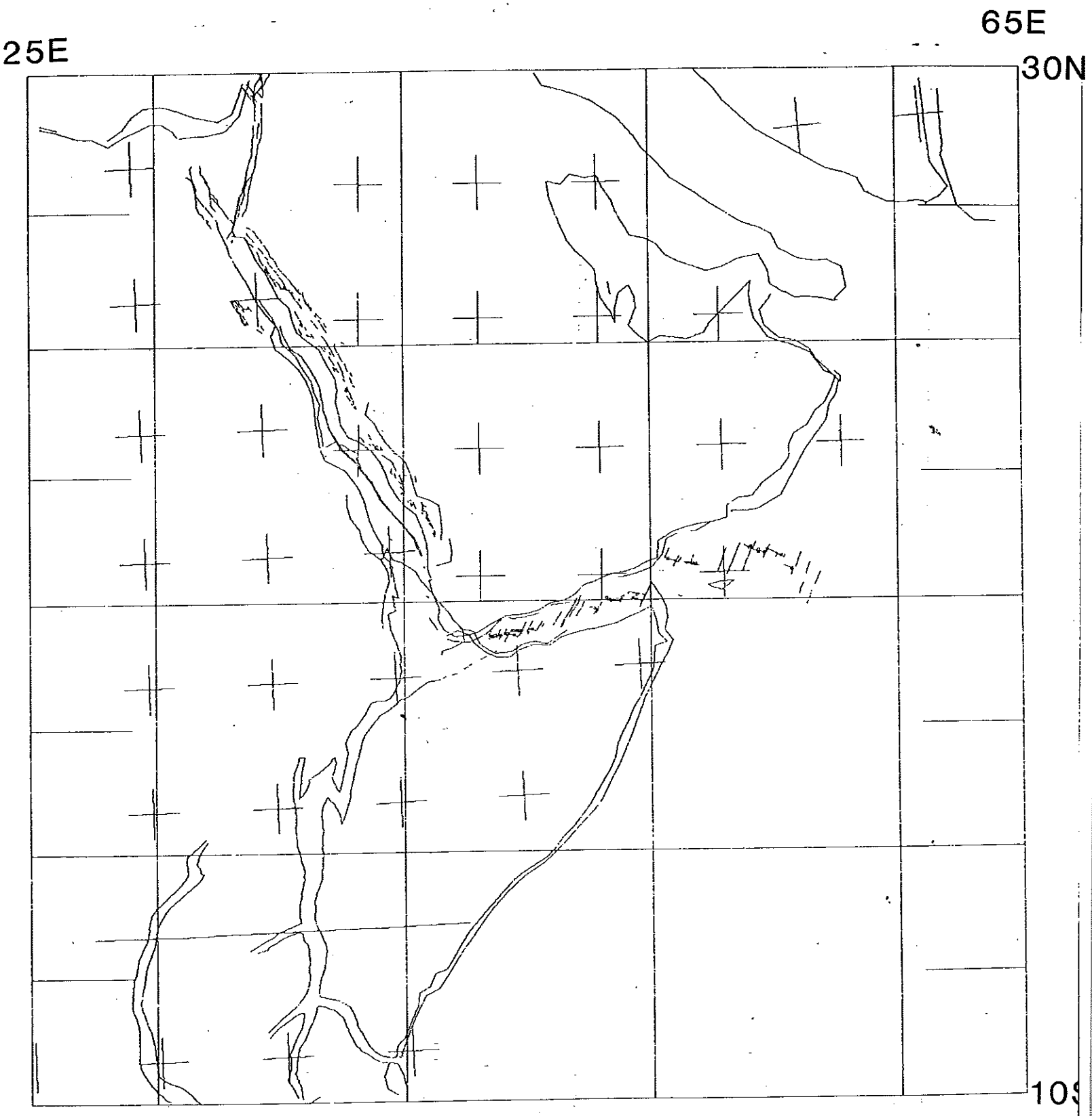

FIGURE 2. Anomaly 5 (10.6 Ma)

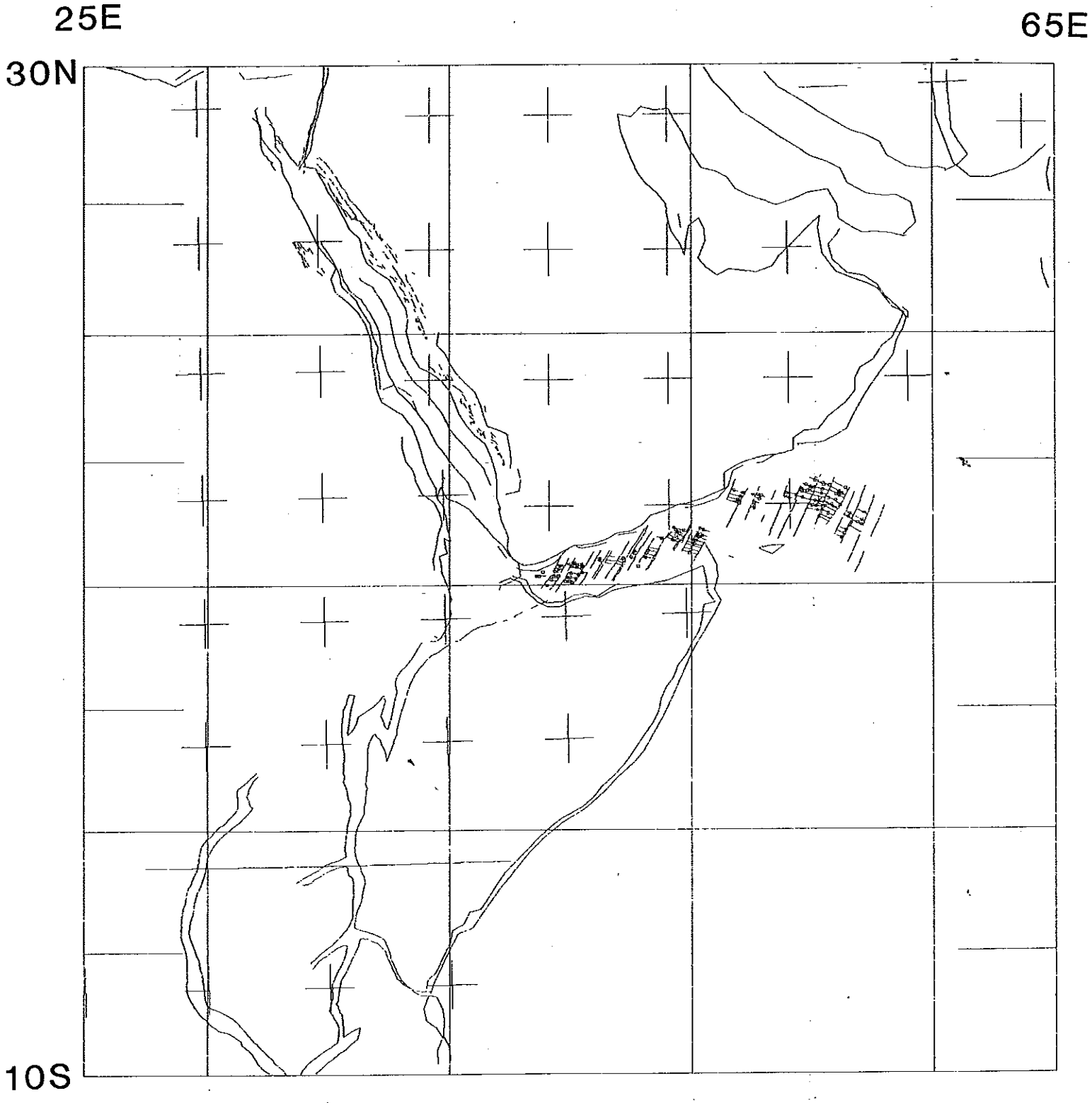

FIGURE 3. Anomaly 3 (4.8 Ma)

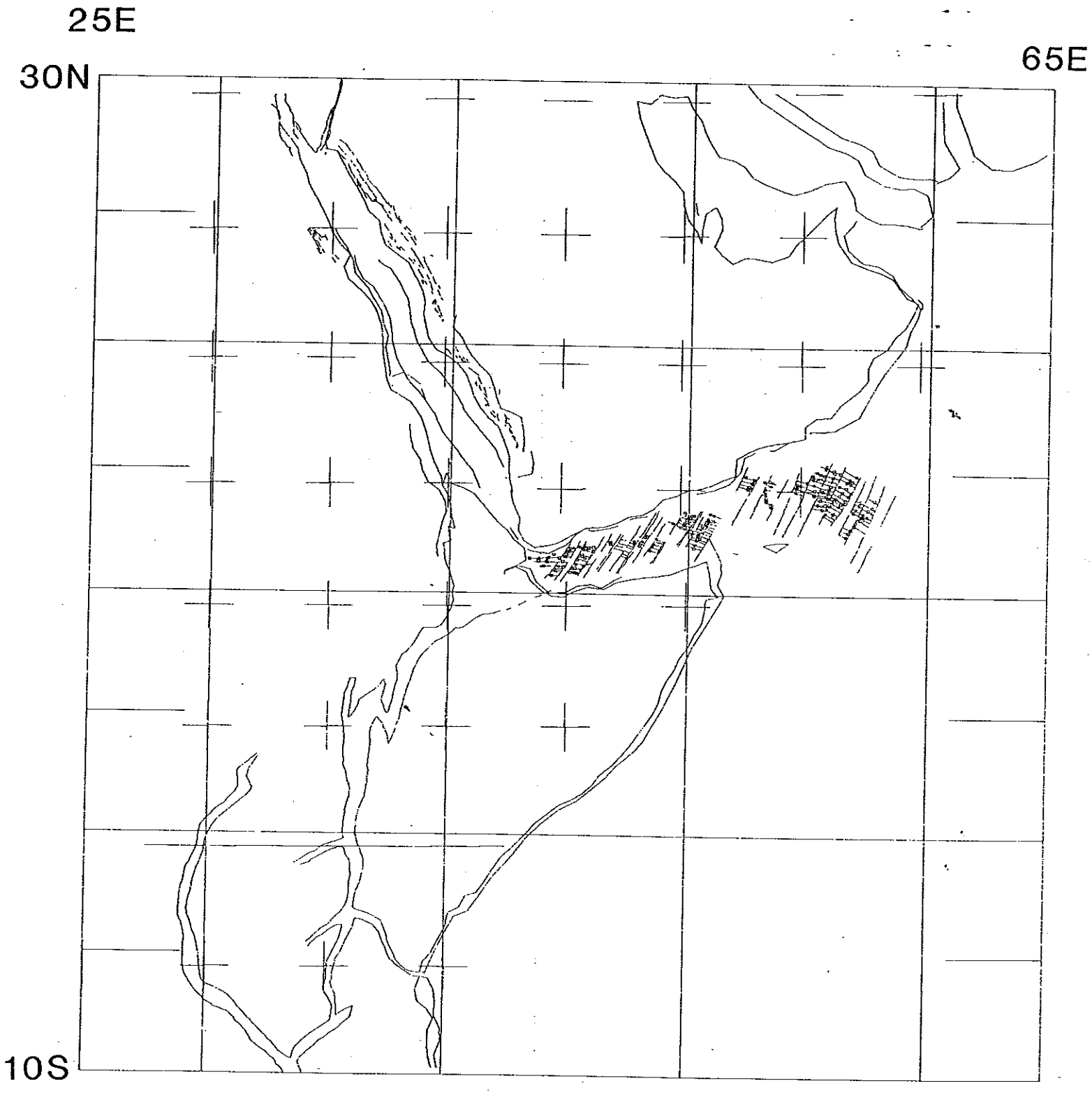

FIGURE 4. Anomaly 2 (1.9 Ma)

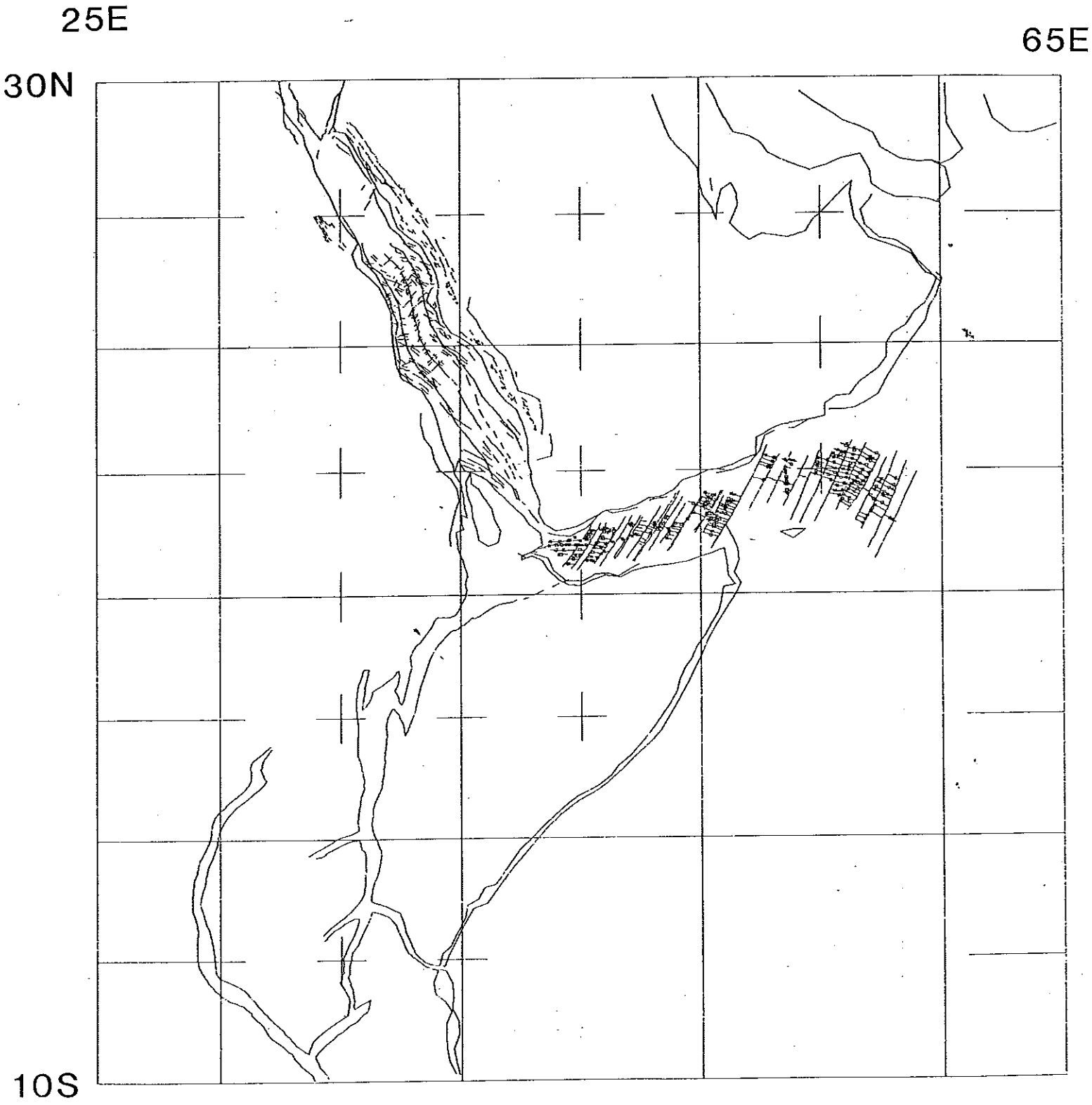

FIGURE 5. Present Day