A GEOLOGICAL TRANSECT ACROSS THE CREST OF THE EAST PACIFIC RISE AT 21°N LATITUDE MADE FROM THE DEEP SUBMERSIBLE ALVIN

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Abstract. This paper is a report of geological observations made using the submersible ALVIN on the crest of the East Pacific Rise near 21°N. The profile is 6 km long and crosses a 5-10 km wide plateau which rises 100 m ± above the rise flanks. At the axis are exposed fresh glassy pillow lavas with no sediment accumulation in a region termed the neovolcanic zone. This zone is about one kilometer wide and includes elongate ridges of pillow lavas and seventeen hydrothermal vent fields in the study area. Outside the neovolcanic zone the seafloor is extensively fissured in another zone which is up to two kilometers wide. The neovolcanic zone and the fissured zone are included within a rift valley or graben about 3 to 5 km wide and 50 m ± deep. This rift valley is asymmetrically located on the west side of the axial plateau; the neovolcanic zone in the study area is asymmetrically located on the east side of the rift graben. Fissured crust is not common outside the rift graben or in the neovolcanic zone; similarly, large throw faults such as those which form the edges of the graben are not found outside of it. These observations can be interpreted according to a volcanic-tectonic cycle in which volcanic eruptions and hydrothermal circulation are followed by a tectonic phase which includes fissuring and vertical movements. When a new cycle starts it may involve a lateral shift of the spreading axis. Lavas along the dive profile are suggested to be no older than a few thousand years based on sediment accumulation. In contrast, seafloor spreading rates here predict crust up to 10⁵ yr old. This observation suggests that lavas from the neovolcanic zone can spread laterally about a kilometer or more and overlap on older crust.

1. Introduction

In this paper we describe and discuss the geological observations made from the deep submersible ALVIN during a traverse that was made largely for conducting on-bottom gravity measurements on the crest of the East Pacific Rise at 21°N. At this location, known as the RISE study area, mineral-laden hot waters (350° C) venting through several meter high sulfide chimneys were first discovered in 1979 (Spiess et al., 1980; Figure 1). We have interpreted our observations here in terms of a description of a three component plate boundary zone, and also in regards to the evidence for a magma chamber at depth.

The definitions of a plate boundary zone at a spreading center follow those of Luyendyk and Macdonald (1976) and Macdonald (1982). Astride the axis of the spreading center is the crustal accretion zone, the region where 95% of the crust is of Holocene age. The outcrop expression of the crustal accretion zone is the neovolcanic zone. This zone is usually less than 1–2 km wide. On opposite sides of the neovolcanic zone is an area of seafloor cut by numerous fissures termed the zone of crustal fissuring and is about 0–2 km wide. Adjoining this zone is the active

Fig. 1. Chart showing the main RISE dive site on the East Pacific Rise crest at 21°N. Also shown in the site of the dive operations in the “Reversal Area” described in a companion paper to this article (Macdonald and Luyendyk, 1985). Bathymetry is shown in meters (after unpublished charts from the Scripps Institution of Oceanography, J. Mammerickx, personal communication, 1980).