Flow patterns in the mantle diapir of the Troodos ophiolite, Cyprus

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INTRODUCTION

The Troodos ophiolite is interpreted as being a slice of oceanic crust perpendicular to the trend of an oceanic spreading ridge, and contains one exposure of ultramafic tectonite from the base of the classic ophiolite sequence. This exposure is located around the highest mountain on the Troodos Range, Mount Olympus in a roughly circular shape. The harzburgite in this section is particularly interesting because it contains a foliation and lineation that can be related to shear planes and resulting mantle flow patterns frozen into its structure. Similar patterns have been studied in the Oman ophiolite, where four distinct types of mantle flow have been distinguished (Ceuleneer et al., 1998) . The Troodos peridotite most closely resembles diapir-type flow.

Mantle diapir model. Upwelling of magma occurs along ridges at mantle plumes beneath the ridge called diapirs. Partially melted peridotite flows up in a cylindrical pattern at the ridge, dipping steeply away from it but rotating to horizontal as flow diverges. Mantle is plastically deformed along shear planes such that the center is moves upwards with respect to the rest of the mantle (Figure 1). Foliation in the form of mineral alignment forms at an angle oblique to shear, dipping away from the ridge axis.

A diapir feature is only preserved if it is either related to an off ridge spreading feature such as a seamount, or it is a slice of the active part of the ridge that is included in the ophiolite (Nicolas et al., 1988). The latter condition is true, since Troodos formed in a supra-subduction zone spreading environment (Robinson et al.,1990). Thus, the mantle diapir can be related to the proposed Solea Graben (Hurst et al., 1994), with paleo-ridge axis almost directly north of the harzburgite exposure.

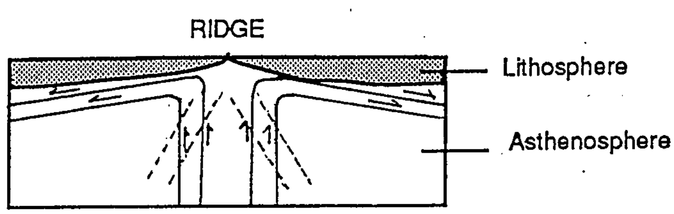

Figure 1: Cross section perpendicular to a ridge axis snowing asthenosheric flow lins (solid lines) with shear sense indcated by arrows. Dashed lines mark foliation traced as mineral elongation resulting from shearing.

METHODS

Field methods. Field mapping of the foliation and lineation defined by elongate orthopyroxene grains in harzburgite was systematically completed during June-July 1995 using a brunton compass. This fabric is most easily detectable in the weathered surfaces of the rock. Due to steep topography, the harzburgite was mainly studied in road cuts and along hiking trails around Mount Olympus in the western, least serpentinized area of the peridotite exposure. Oriented samples were collected that spatially represented the entire section.

Laboratory methods. The objective of laboratory studies was to determine the true orientation of planes and lines of deformation in olivine grains. These can be related to field fabrics in order to find the direction of shearing of the rock. First, the oriented samples were cut for making thin sections in three perpendicular directions: one in the plane of foliation, one parallel to lineation and perpendicular to foliation and a third perpendicular to both foliation and lineation. These cuts are made to ensure complete coverage of different directions of the sample. The thin sections were analyzed using a universal stage which allows one to measure the orientation of crystallographic axes and planes. I determined these for olivine grains in each thin section, and then plotted their orientations with respect to field coordinates. In particular for olivine, a dominant slip system related to plastic deformation can be found that relates to shear planes. The shear plane is easily determined graphically.

DATA

Field measurements. Orientation of the foliation in the field rotates from north striking to northwest striking from the northern to the southern part of the harzburgite section along the western side (Figure 2) Lineation was difficult to measure in weathered outcrops but was determined from oriented samples, and trends towards west, plunging moderately to steeply.

Kinematic analysis of microstructures. From universal stage measurements, crystallographic axes [100], [010], and [001] of olivine grains plot in clusters for each sample and are oriented ninety degrees from each other. Axis [100] plunges steeply to the southeast, [010] plunges moderately to the northwest, and [001] plunges steeply to the northeast for a sammple from the western side of the field area. It is possible to determine the slip system operating in the olivine by relating these axes with the field foliation and lineation (Shelly, 1983). For Troodos, the [100] axis is close to the lineation with (010) at a high angle, indicating (010) [100] slip, the most common natural-fabric pattern, (Shelly, 1983). See figure 3.

The [100] axis is 20° oblique to foliation when plotted vertical with lineation horizontal with a dextral sense of shear when rotated to true field orientation. This corresponds to northeast side moving up. With respect to the Solea Graben spreading axis (Hurst et al, 1994), the mapped part of the diapir formed on the western flank of the ridge. If figure 1 is a cross section looking north, the left side of the diagram illustrates the geometric relationships.

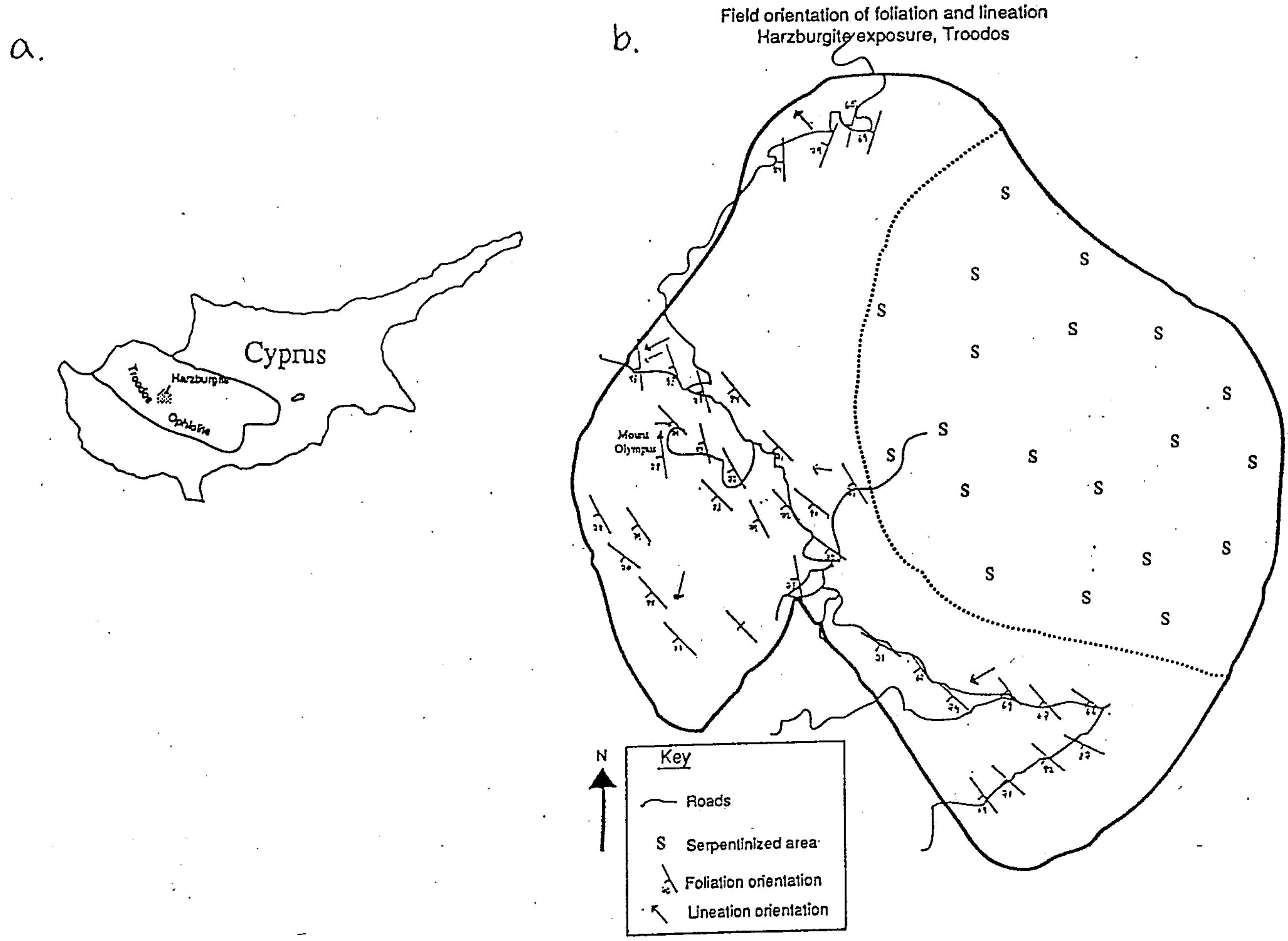

Figure 2a.: Cyprus location map showing harzburgite study area stippled. **b.** Field data showing foliation and lineation orientations.

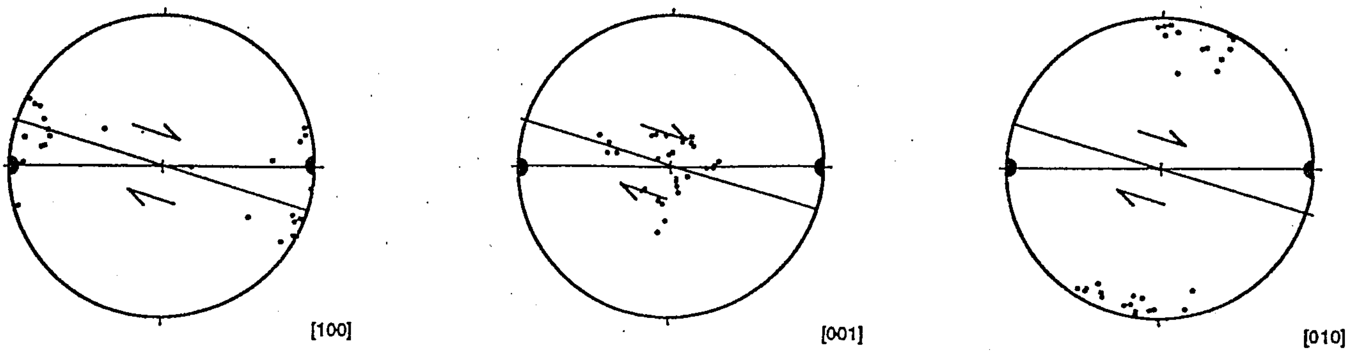

Figure 3: Crystallographic axes of olivine plotted with foliation vertical and lineation horizontal. Oblique line is shear plane. Dextral shear sense indicated.

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