A PRELIMINARY ANALYSIS OF LUNAR EXTRA-MARE BASALTS: DISTRIBUTION, COMPOSITIONS, AGES, VOLUMES, AND ERUPTION STYLES

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Abstract. Extra-mare basalts occupy 8.5% of the lunar basalt area and comprise 1% of the total mare basalt volume. They are preferentially located where the crust is thin and topographically low. In terms of age, eruption style, and composition they are as variable as the mare basalts. In some instances extrusion in extra-mare craters was preceded by floor-fracturing whereas in other cases it apparently was not. The volume of lava erupted may have been controlled more by the volume of magma produced than by hydrostatic effects. A minimum of nearly 1300 separate basalt eruptions is indicated; the true value could be nearer 30,000 separate eruptions.

1. Introduction

Previous studies (Head, 1975; Scott et al., 1977a) have illustrated that lunar mare basalts are preferentially located in topographic lows (usually impact basins) and occupy about 16% of the lunar surface area (Figure 1a). Although the majority of these basalts are found in the near side equatorial region, nearly one fifth of the total basalt area is located in the poorly studied polar and far side regions (Figure 1b). The present study characterizes the different basalt environments as delineated by units mapped by the U.S. Geological Survey as erupted basaltic materials (Wilhelms and McCauley, 1971; Wilhelms and El-Baz, 1977; Scott et al., 1977b; Lucchitta, 1978; Stuart-Alexander, 1978; Wilhelms et al., 1979). A few minor areas were added, whereas areas mapped as 'marets' (Beals and Tanner, 1975) and impact redistributed mafic materials (Schultz and Spudis, 1979) were omitted. The present study focuses on the basalts emplaced in extra-mare environments, that is, basalts not within the named maria (Table I) but which appear to be of the same composition as mare basalts. These extra-mare basalts comprise only about 8.5% of the total basalt area (Figure 1c), but occur within excess of 300 separate locations. Unlike the large maria where repeated eruptions and flooding of older basalts has been commonplace (Whitford-Stark, 1980a), the morphologies of basalts within these extra-mare locations can more readily be employed to determine the eruption style.

2. Distribution

The extra-mare basalts were divided into three groups; those within 'lowlands', those within floor-fractured craters, and those within unfractured craters (Figure 1d). Lowlands were defined as areas not enclosed by a single uninterrupted crater wall (or doublet) and primarily occur peripheral to the major maria or partly flood the rings of large basins.
Fig. 1. Pie-graphs showing the percentage areas of basalts in different environments. The scale progressively decreases from A to D.

Figure 2 illustrates the distribution of mare basalts and includes the outlines of far side and polar impact basins and the contour of mean lunar radius of 1737.42 km derived from a global harmonic topographic model by Bills and Ferrari (1975). A previous study by Scott et al. (1977a) noted that most of the far side basalts were located in old impact basins though some basins (e.g., Korolev, Hertzsprung, and Mendeleev) exhibit no surface evidence of past basaltic volcanism. Additionally, Schultz and Spudis (1979) found few dark halo craters of impact origin within far side basins. These dark halo craters are interpreted by them to excavate mafic materials from beneath later ejecta deposits. The absence of such craters on the lunar far side would imply that mafic materials have been buried by a substantial thickness of material which impact craters have been unable to penetrate, that volcanism did not take place, or that the products of volcanism were of different composition to mare basalts. If mafic material were present at depth within basins such as Korolev, it would have been excavated by the large (> 35 km diam) craters superimposed on that basin. On the basis of gamma-ray data, Spudis (1979) has suggested that far side volcanism may have been of KREEP composition, particularly since a radioactive high occurs in the Van de Graaff region. Limited surface coverage of the Apollo orbiter groundtracks precludes definition of the extent of such KREEP-rich materials, and extensive surface