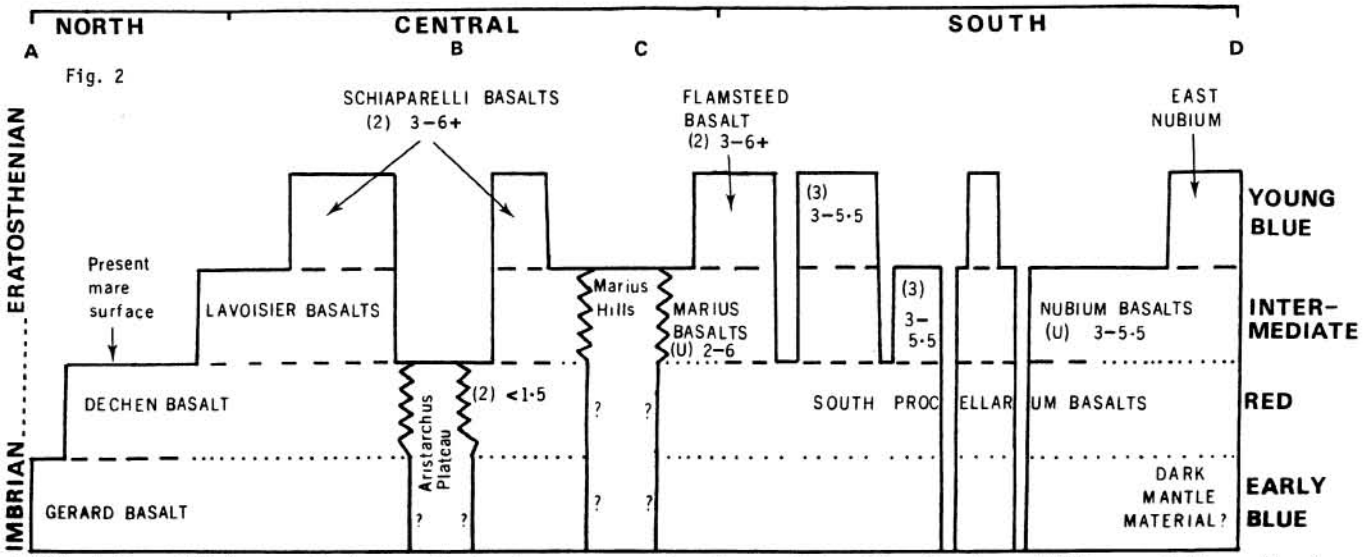
OCEANUS PROCELLARUM: PRELIMINARY BASALT STRATIGRAPHY AND EMPLACEMENT HISTORY. James L. Whitford-Stark and James W. Head, Dept. of Geological Sciences, Brown University, Providence, RI 02912.

The western nearside mare region (Oceanus Procellarum) (Fig. 1) is the largest area of mare lavas on the Moon and its morphological characteristics lie in contrast to many aspects of the circular basins[1], including its large and irregular size, the presence of major volcanic complexes[2], and the absence of associated young impact basins. In our previous work, we have mapped the characteristic volcanic and tectonic features of the Procellarum-Nubium region, contrasted the styles of volcanism in the three major complexes, and compared the volcanic and tectonic evolution of Procellarum with circular mare basins[1,2]. Here we define major geologic units in Procellarum, present a preliminary basalt stratigraphy, and discuss aspects of the emplacement history. Geologic units have been defined, characterized and mapped on the basis of a variety of remote sensing data[3] including color-composite photography[4], spectral images[5,6], spectral reflectance measurements[7], and orbital geochemical information[8]. Preliminary age relationships were established using crater degradation ages and stratigraphic techniques, and major units were assigned informal names related to their geographic position or to prominent nearby features such as craters. A summary of the preliminary basalt stratigraphy is presented in Fig. 2. Sequence of Emplacement - Oceanus Procellarum was filled by four major basalt units. Stratigraphic sequence can be established on a local and regional scale but emplacement of succeeding units may have overlapped in the basin as a whole. The Gerard basalts (blue) are the earliest mare unit yet detected in Procellarum. They crop out at the NW edge, and probably correlate in terms of age and composition to Apollo 11 and 17 basalts. We have not yet found evidence for their presence elsewhere in Procellarum, although the dark mantle in the uplands east of Copernicus may correlate with this unit in the subsurface[10]. The Dechen basalts (red) show offlap relationships with the Gerard basalts in the NW, and similar units are associated with the Aristarchus Plateau[11] and the South Procellarum region. The Dechen basalts are overlain by the Lavoisier basalts (intermediate) in the NW. This type of unit occurs throughout Procellarum, cropping out prominently in the Marius Hills and Nubium region and includes Apollo 12 lavas. The youngest sequence to be emplaced in Procellarum (blue) forms surface flows in the north, surrounding the Aristarchus Plateau[11] (Schiaparelli basalts), floods Flamsteed[12], and occurs in east Nubium, and elsewhere. This young blue sequence generally correlates with the latest flow sequence in Mare Imbrium[13]. Areal Distribution - The emplacement of each succeeding unit, and downwarping coincident with emplacement[1], obscures evidence for the distribution and thickness of earlier units. Evidence for the presence of early blue lavas is presently restricted to the NW and possibly to the east, but they may have underlain the whole basin. Red and intermediate are exposed in all three major sections of Procellarum and thin flows of young blue basalts cover local areas throughout Procellarum. Source Regions - Evidence for lava sources is provided by location of sinuous rilles, domes, cones, and complexes[1,2]. Preliminary analysis shows no evidence for sources in the small area of exposure of early blue lavas. Red lavas were produced at the Aristarchus Plateau and probably other



unidentified localities. Intermediate lavas can be traced to the Marius Hills and Mons Rumker complexes[2] while young blue lavas appear to have issued from central vents located at the highland/mare borders, mare ridges, and the dome complex just west of Copernicus. Volumes - Analysis of volumes of the various phases is presently underway. Preliminary results indicate volumes for the young blue deposits of about 0.03×10^6 km^3, which comprises less than about 10% of the total lava. Intermediate lavas appear to form a larger part of the volcanic fill than any of the other units, and the total volume of Procellarum is extremely small compared to the total volume of the lunar crust (<<1%)[14]. Tectonic/Topographic Evolution and Style of Mare Emplacement - Northern Procellarum has undergone broad downwarping toward the basin center resulting in offlap relationships between lava sequences. Central Procellarum underwent similar but more extensive downwarping, accompanied by extensive early linear rille development along the western margin and resulting in possible onlap relationships and thicker accumulation of lavas. Southern Procellarum and Nubium underwent little regional downwarping and are characterized by multiple kipukas (remnants of highland topography surrounded by remnants of early mare deposits) and relatively thin total mare fill. Downwarping throughout Procellarum produced mare ridges[1] which locally controlled the distribution and shape of the latest flows. The lack of correlation between the distribution of young blue lavas and present topography strongly suggests continuation of subsidence of Procellarum into the last 3 b.y. Relationship to Other Stratigraphic Markers - No evidence has yet been found for superposition of Imbrium or Orientale ejecta on the mare deposits described here. Highland basalts were emplaced prior to the maria in at least some areas[15] and non-mare volcanism may have been synchronous in a few areas[16,17].

OCEANUS PROCELLARUM STRATIGRAPHY AND EMPLACEMENT

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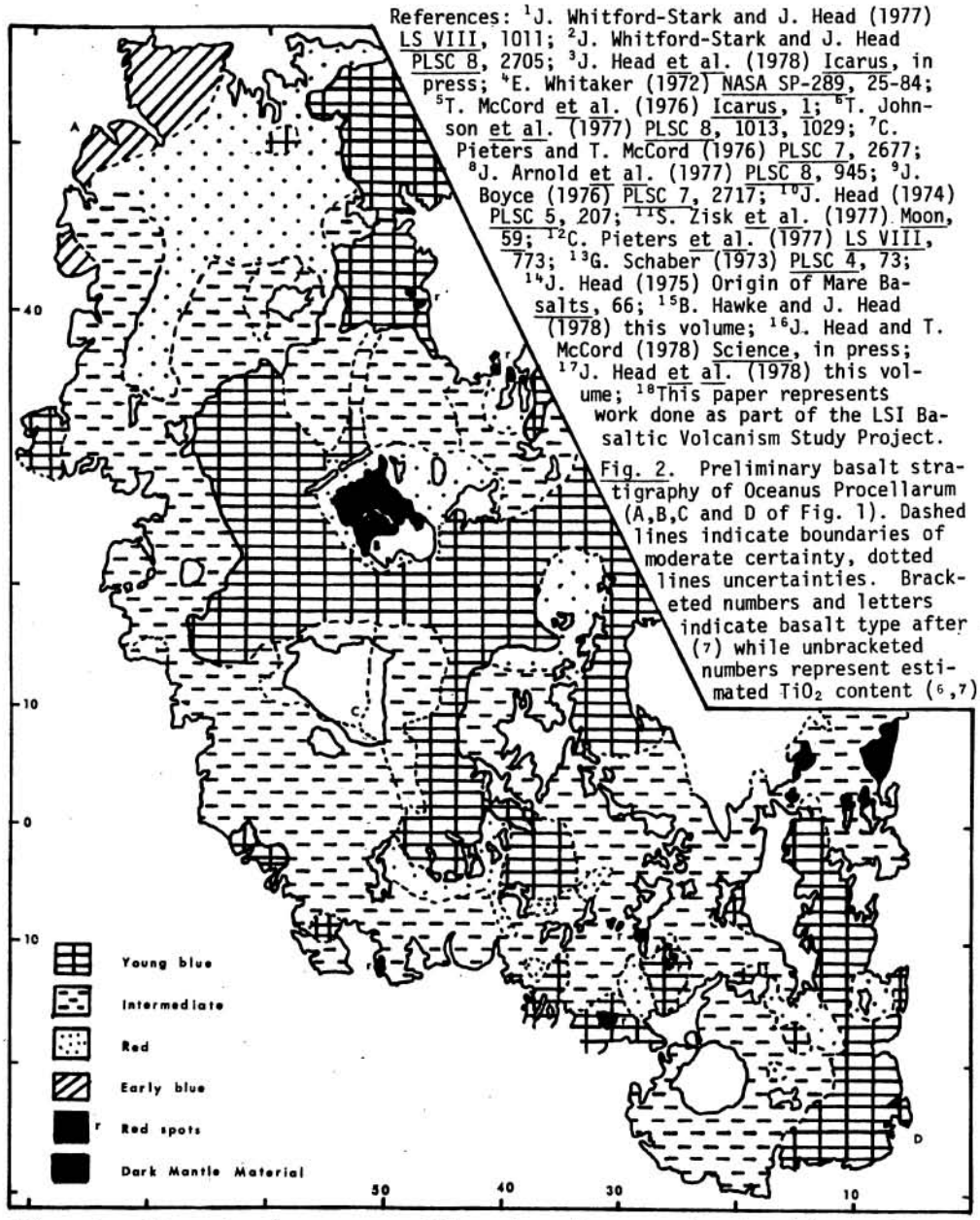

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Fig. 2. Preliminary basalt stratigraphy of Oceanus Procellarum (A,B,C and D of Fig. 1). Dashed lines indicate boundaries of moderate certainty, dotted lines uncertainties. Bracketed numbers and letters indicate basalt type after (7) while unbracketed numbers represent estimated TiO_2 content ([6],[7]).

Fig. 1. Map showing compositional and age relationships of mare basalts in Oceanus Procellarum. Methods of data acquisition are described in text.