MAFIC MAGNETIC VOLCANICLASTIC DUNES: A POSSIBLE MARS ANALOG IN THE ANDES OF ECUADOR. J.R. Zimbelman[1] and K.S. Edgett[2]; [1]CEPS/NASM, Smithsonian Institution, Washington, D.C. 20560, [2]Dept. of Geology, Arizona State Univ., Tempe, AZ 85287-1404.

A field of dark sand dunes is located in the InterAndean Valley of central Ecuador (1°50' to 2° 10' S, 78°40' to 50' W), approximately 50 km south of the city of Riobamba. The low albedo of the sand results from a predominance of dark grains, a significant fraction of which are strongly attracted to a magnet. The source of the dark sand grains is not readily apparent in the vicinity of the dunes, but an exposure of multi-layered mafic ash 4 km WNW of Riobamba forms piles of loose grains visually identical to the dark dunes further south. No volcanic center is adjacent to the dune field, but both the dunes and the Riobamba ash are located along the predicted fallout direction for eruptions of Sangay volcano, a basaltic-andesite stratovolcano 46 km E of the dunes. The dark dunes in Ecuador are an example of a rare class of mafic volcaniclastic dunes documented on Earth. The Ecuador dunes are of particular interest because both the mafic content and the significant fraction of magnetic grains makes these aeolian-reworked volcaniclastic products candidate analogs to the dark dune fields on Mars.

The country of Ecuador is crossed by the NNE-trending Andes Mountains, the "backbone" of the South American continent. Quaternary volcanoes form the highest peaks of the Ecuadoran Andes; they are divided into two ranges separated by the InterAndean Valley, a graben filled with Cenozoic sedimentary and pyroclastic deposits [1]. The dark aeolian dunes occur at the southern end of the InterAndean Valley along the Pan American Highway, south of Riobamba (Fig. 1). Patches of dark sediment near Guamote and Palmira form sand sheets and isolated transverse and barchan dunes. South of Palmira, dunes of 1-2 m height were sampled and photographed in December 1993. Subsequent study of maps [2] and aerial photographs [3] showed that the sand sheets and dunes cover about 250 km^2 around Guamote and Palmira (Fig. 1). No outcrop of the source material for the dark sand was evident in the vicinity of the sand dunes. However, 4 km WNW of Riobamba, outcrops of 20-30 cm of dark volcanic ash were observed draped over the topography; this ash weathers into piles of dark sand that are visually identical to the dune sand further south. Sieving shows that the ash is poorly sorted relative to the dune sand, but both samples have peak abundances of fine sand (ϕ = 3; 180 to 125 μm) with similar distributions for finer particles. Some particles in all size fractions are strongly attracted to a magnet, as is >30% (by mass) of the bulk dune sand sample.

Where did the dark volcanic ash come from? The closest active volcano is Sangay, 46 km east of the sand locality (Fig. 1). Sangay is one of the most continuously active volcanoes in the world [4], but it's relative inaccessibility has led to only limited study. Sangay is a stratovolcano of basaltic andesite composition (SiO_2 of 56%) which produced a "rain of ash on Riobamba, Guamote, and Palmira" [4]. These towns are in the direction of the most probable ash fall-out from Sangay [5]. Early records of European settlers indicate that the ash layers we sampled in Riobamba may be from violent explosions on Sangay which produced "ash rains in Riobamba" in

1728 [6]. Thus, stratovolcanoes like Sangay may be a source of mafic-rich ash which is then reworked by the wind to form dark sand dunes.

Dunes composed of mafic sands are quite rare on Earth. Some of the best examples of such dunes occur in Washington, Hawaii, Arizona, and Iceland, where the dunes are usually formed from reworked pyroclasts [7]. The Ecuadoran dunes described above are particularly relevant as possible analogs to dunes on Mars because they appear to be linked to a dark volcanic ash from a specific volcano and because they contain an abundance of magnetic materials.

Aeolian dunes on Mars tend to have the lowest albedoes of any Martian surface material [8]. The best spectral evidence suggests that dark regions on Mars include relatively unoxidized mafic materials like pyroxene [9-10]. Most dark dunes on Mars are probably composed of mafic or ultramafic minerals, lithic fragments, and/or glass [7,11-13], but other compositions have also been suggested [12-18]. In particular, Herkenhoff [18] advocates that some dark dunes are aggregates of magnetic dust, consistent with evidence of 1-7% magnetic material (magnetite or maghemite) in the surface fines at the Viking lander sites [19]. The magnetic dark sand in Ecuador provides an analog for an alternative mechanism to account for the magnetic materials in the Martian soil.

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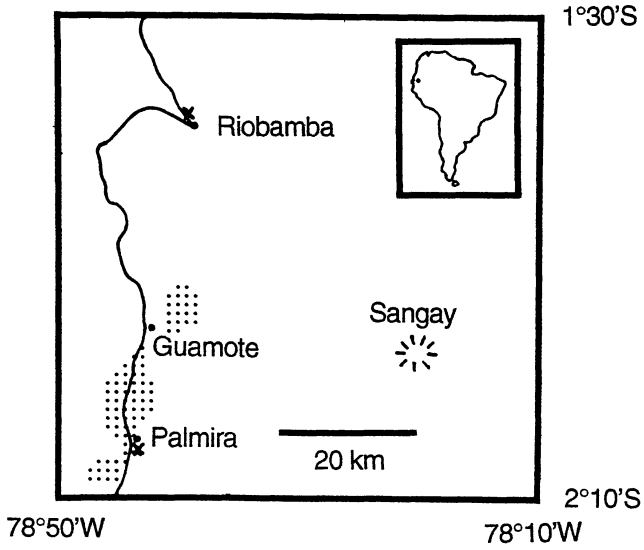

Figure 1. Location map for mafic volcaniclastic dunes in Ecuador. Pattern = dunes and sand sheet; Large dot = Riobamba, Guamote, and Palmira along Pan American Highway; X = sample locations; Hachures = Sangay stratovolcano.