The Strombolian eruption style and volcanic eruptions from Stromboli
By Raffaello Lena

Introduction

Volcanic eruptions created lava flows, pyroclastic deposits, pits, and domes on the Moon. The same process continues to operate on Earth, most reliably visible at Stromboli volcano which has erupted for more than a millennium (Wood, 2008; see also Alean and Fulle, stromboli online). Some of the lunar pyroclastic deposits on the moon have been described and modelled as compatible with a Strombolian or Vulcanian style of eruption.

General overview

More than 100 lunar pyroclastic deposits have been recognized and classified as *small* and *regional* deposits on the basis of size and morphology (Gaddis et al, 2003 and references therein). Characterization of the nature of the lunar pyroclastic deposits (LPDs) is essential for models of formation, segregation and emplacement of lunar magmas.

There are two styles of volcanism that might leave dark mantling units on the moon. Regional deposits are thought to have been emplaced as products of continuous or Strombolian-style eruptions, with wide dispersion of well-sorted pyroclasts (Gaddis et al, 2003). Intermittent or Vulcanian-style eruptions likely have produced the small pyroclastic deposits, with explosive removal of a plug of lava within a conduit and forming an endogenic vent (Head and Wilson, 1979; Weitz et al, 1998).

Thus the Strombolian eruptions may have formed the largest dark mantle deposits on the moon while the Vulcanian eruptions feature short explosions of gas and rocks and tend to be smaller than Strombolian eruptions. Because gases need to build up near the vent, they do not involve large volumes of magma. Hence, Vulcanian eruptions likely form the smaller patches of dark materials on the moon, with a recognizable central pit or vent structure (Head and Wilson, 1979).

Among the largest of the dark mantle deposits are Aristarchus plateau, Mare Humorum, South Mare Vaporum and Sulpicius Gallus deposits.

On the Earth continuous Strombolian explosions, sometimes accompanied by lava flows, have been recorded at Stromboli (Italy) for more than a millennium.

Stromboli, the North East of the Aeolian Islands, is the emergent summit of a volcano that grew in several eruptive periods, the last of which formed the western portion of the island (Fig.1a). Ginostra, located to the West, is likely the smallest port in the world (Fig 1b).

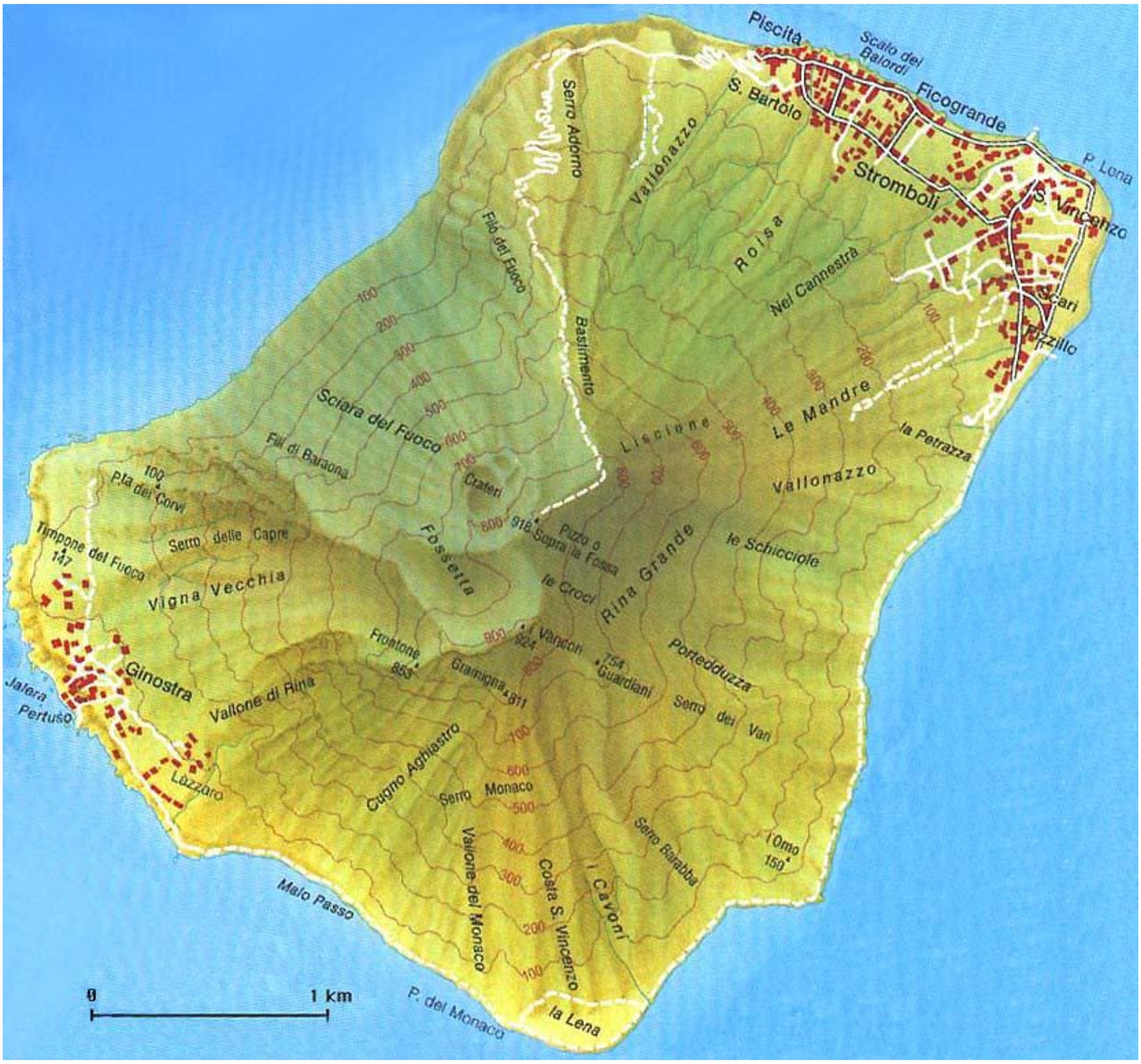

Figure 1a: map of Stromboli.

Figure 1b: Ginostra village (image by the author).

About 200000 years ago, Stromboli had not yet reached sea level but another volcano, called Strombolicchio, was active. Today Strombolicchio is an eroded volcanic neck of basaltic andesitic composition (Fig.2).The geologic evolution of Stromboli volcano is recorded in its subaerial part and four major periods (Paleostromboli, Vancori cicles, Neostromboli, Recent Stromboli) have been recognized and further subdivided in 30 volcanostratigraphic units (Fig.3). These main divisions are defined largely by collapse episodes of the volcanic edifice (Fig. 3). The Vancori products filled the remnants of the Paleostromboli edifice, a caldera formed at the end of the Paleostromboli period (Hornig-Kjarsgaard et al., 1993).

A lateral collapse defines the end of the Vancori period and the Neostromboli collapse, which occurred in the same direction, defines the end of the Neostromboli period (Hornig-Kjarsgaard et al., 1993; Tibaldi et al., 1994; International Geoscience program and references therein). Subsequently, a new vent became active in the area of Pizzo sopra la Fossa (Fig. 1), marking the onset of the recent activity of the volcano. Several smaller collapses have occurred in the same area, forming the Sciara del Fuoco in its present shape and resulting in a highly faulted volcanic edifice. The Sciara del Fuoco formed about 5000 years ago (cf. Fig.4).

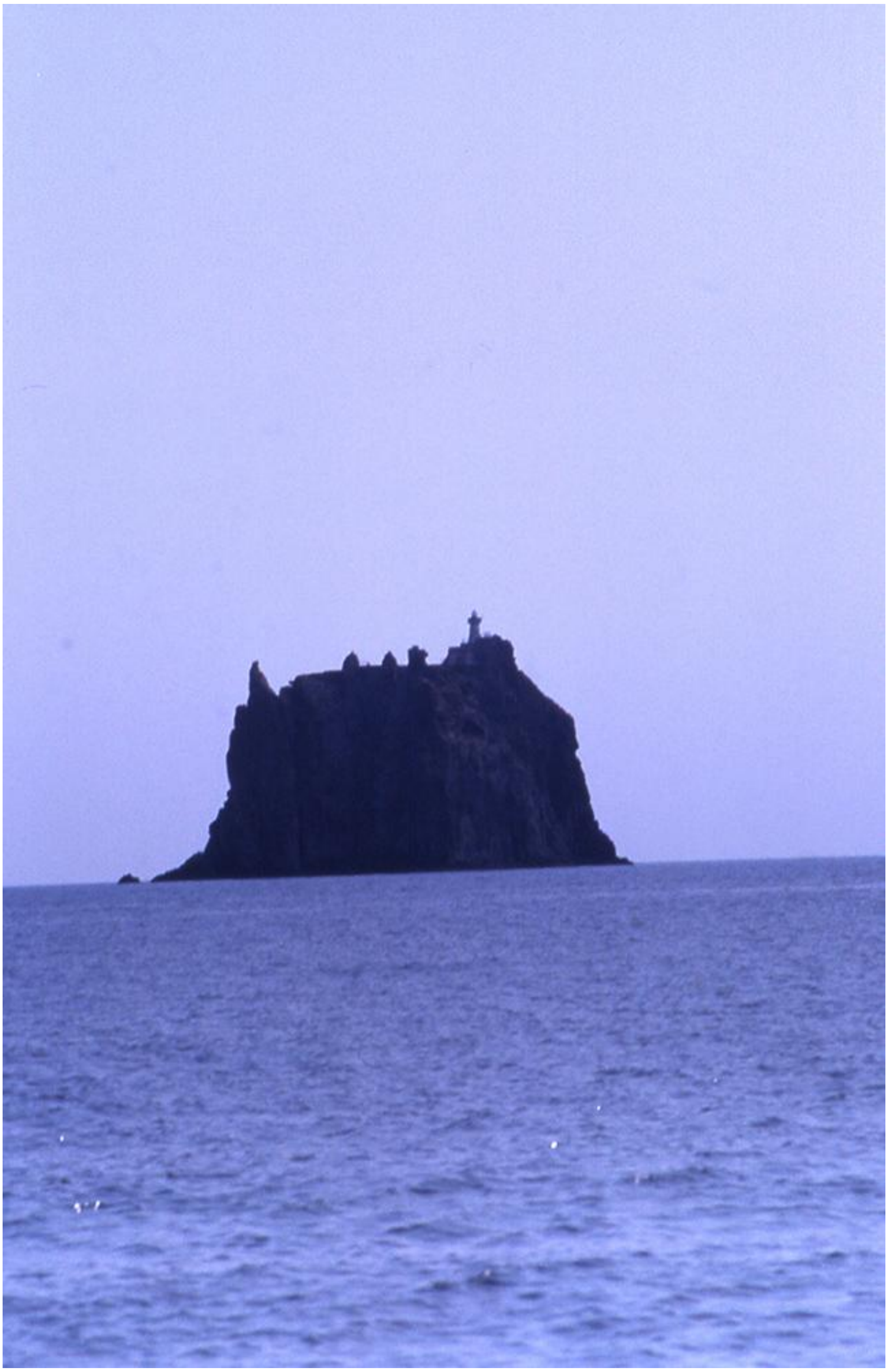

Figure 2: Strombolicchio an eroded volcanic neck (image by the author).

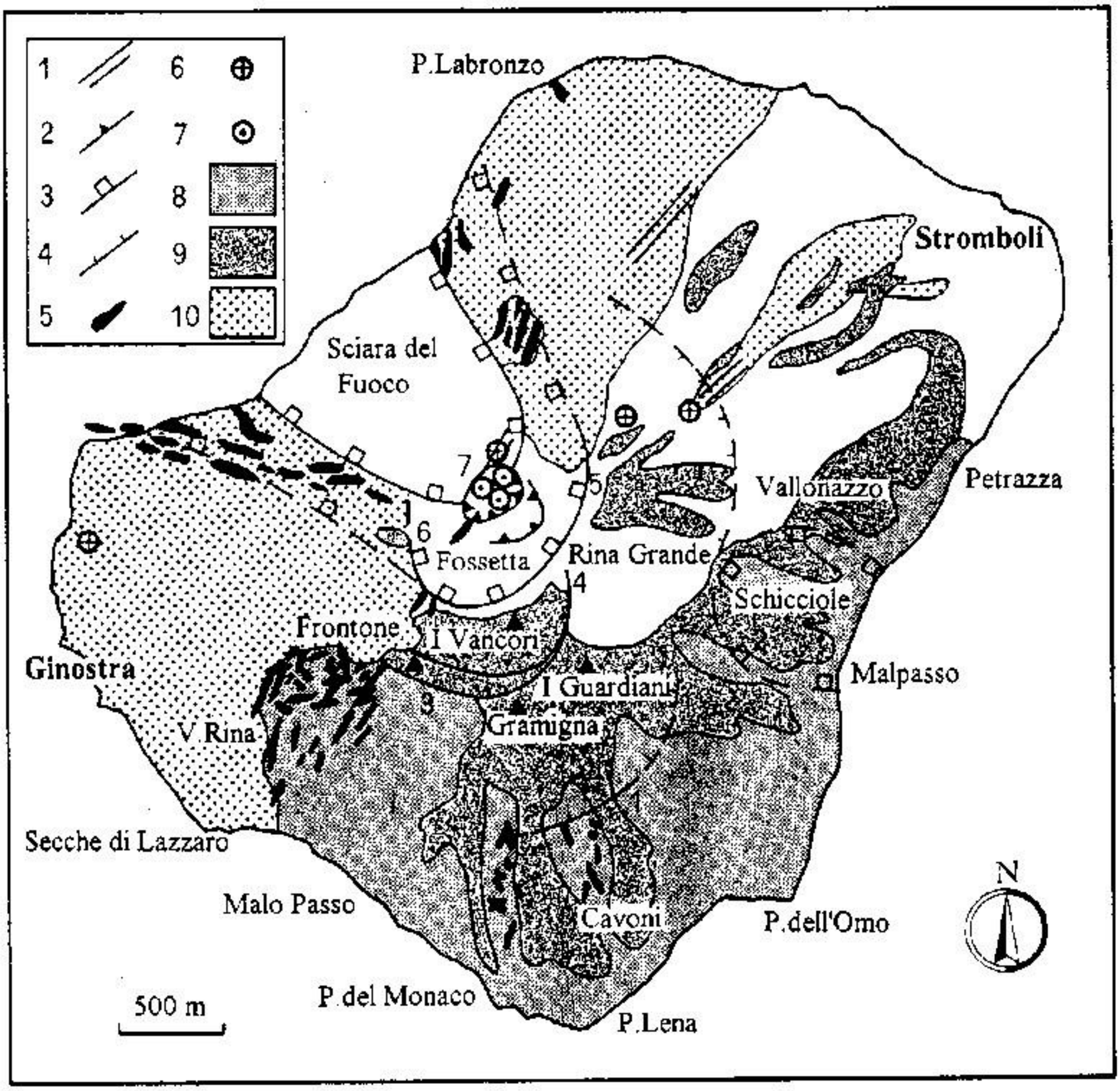

Figure 3: Geologic map of Stromboli; 1, ***eruptive fissure; 2, crater rim; 3, flank and sector collapses; 4, summit caldera; 5, dike; 6, young parasitic vent; 7, active vent; 8, oldest rock units comprising Paleostromboli I, II e III; 9, Vancori series; 10, Neostromboli rocks; in white are the Recent Period deposits (from Pasquarè et al, 1993).***

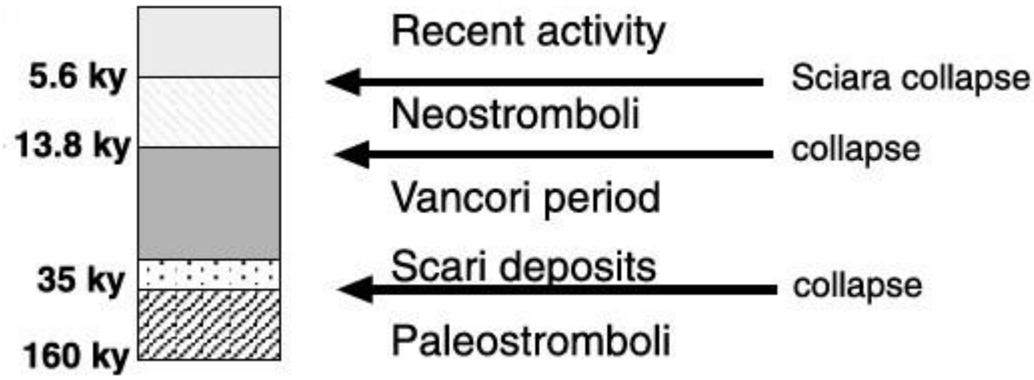

Figure 4: periods of volcanism and collapse in Stromboli.

During the first two periods pyroclastites (ignimbrites, surge and lahar deposits) predominate over lavas. The more recent products are generally basalts and andesites spanning the complete range of subduction-related magma series from calc-alkaline to shoshonitic. The activity of the Vancori and Recent periods is shoshonitic, whereas the Neostromboli period products are richer in potassium (Francalanci et al., 1989).

In locality Piscità (Fig.1) a lava tube is visible, which formed after the surface of a lava flow cooled and solidified, developing a continuous crust beneath which the still molten interior lava continued to flow toward the sea. The active vents are well visible from the Sciara del Fuoco or from the highest peak of the volcano Pizzo sopra la fossa (cfr. Figs. 1 and 3).

The slope below the vents is covered with debris from the October 1993 explosions. Interestingly some small yellowish patches between dark ash located near the crater 1 are apparent. They are remains of Neostromboli volcano, which have been chemically altered by corrosive action of the fumaroles, still visible in the upper portion of the cone.

Figs. 5-10 provide the stratigraphic relationship and the different volcanic products that can be observed today in Stromboli. All the images were taken by the Author.

Figure 5 a: Basalts and scoria from the Paleostromboli volcano (image by the author).

Figure 5b: Basalts and scoria from the Paleostromboli volcano (image by the author).

Figure 6: lava flows and scoria produced from Paleostromboli and Vancori volcano (image by the author) .

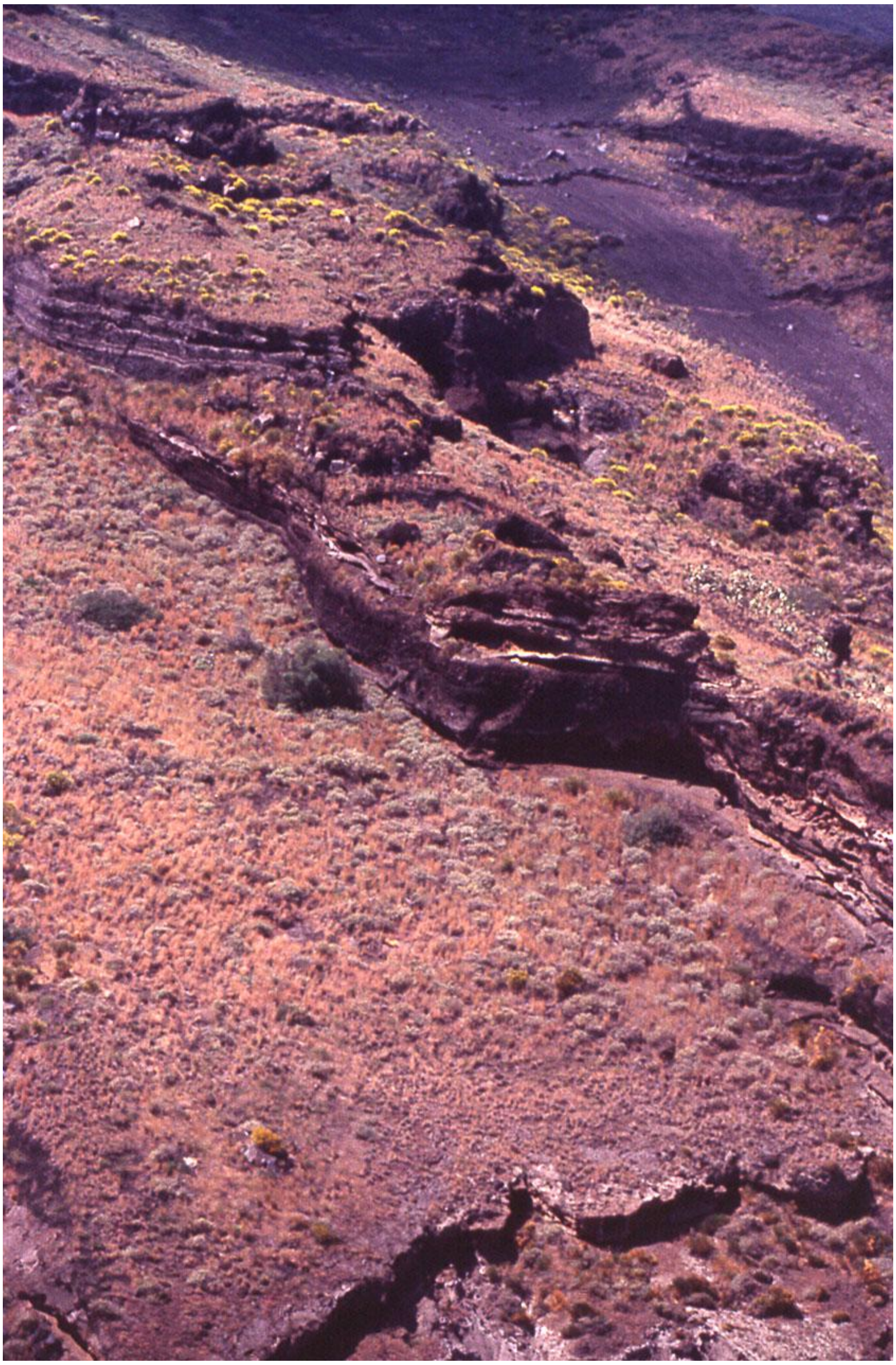

Figure 7: The Vancori volcano has produced explosive eruptions. Ignimbrites, lapilli, solidified lava and pyroclastic deposits are apparent (image by the author).

Figure 8: Volcanic products (scoria and lava flows) from Neostromboli volcano (image by the author).

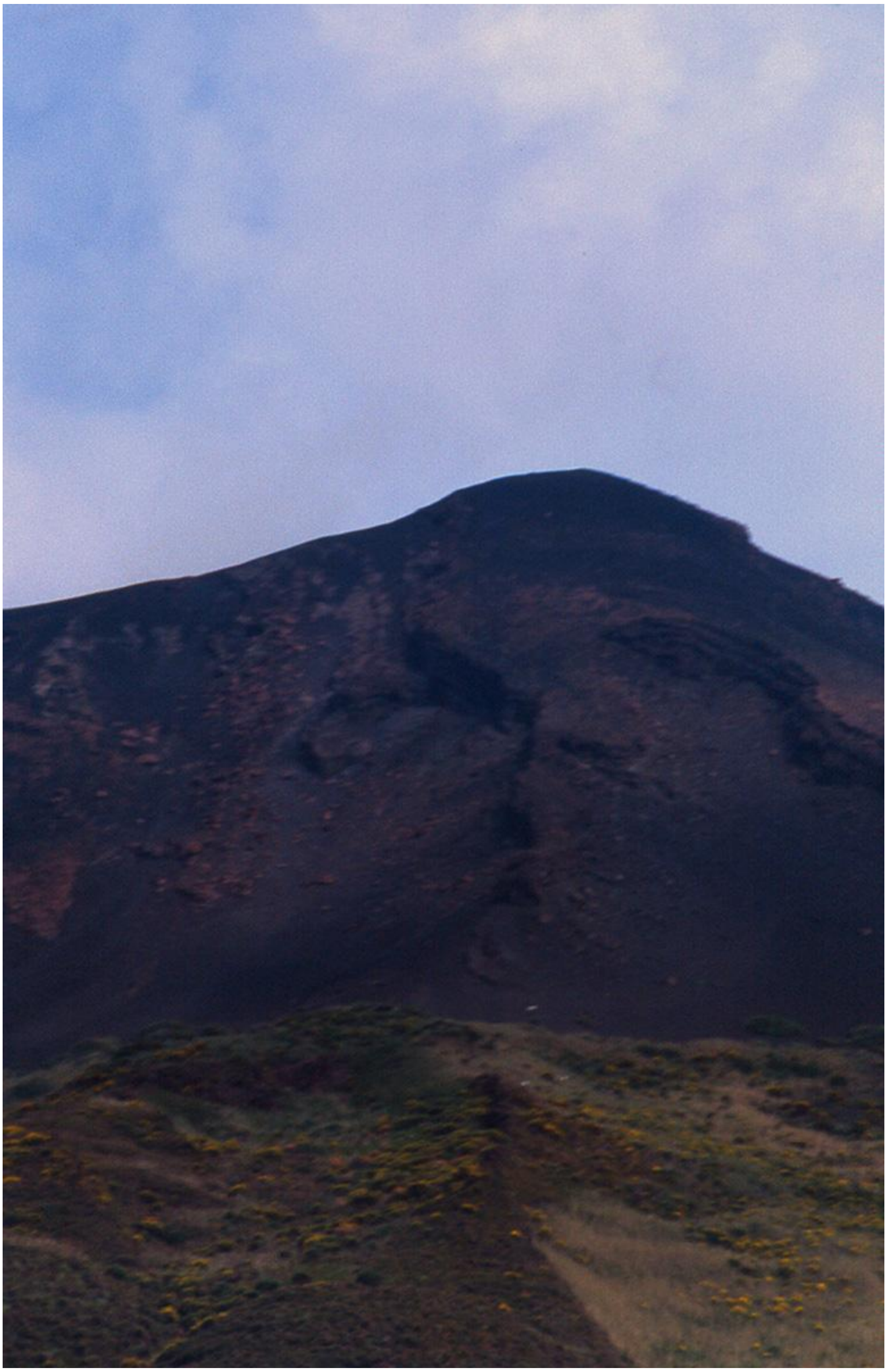

Figure 9: The flank of the ancient Vancori volcano collapsed and was filled with volcanic products of Neostromboli. The surface is covered with ash and debris (image by the author).

Figure 10 a and 10 b: The crater 1 with small yellowish patches remains of Neostromboli volcano. In the two images the plumes produced by small Strombolian eruption are apparent (images by the author).

Eruption style and Mineralogic characteristics

The magmas of the Aeolian Islands are similar to those of volcanoes that make up the "belt of fire" in Pacific ocean. They show, over time, the trend towards ever more basic compositions (lower content of silica) and more rich in potassium. The sample shown in Fig. 11 is an andesite with reddish hue and vescicular texture. The main phenocrysts are plagioclase feldspar and with the presence of pyroxene (clinopyroxene) and olivine. For a detailed account of the mineral chemistry of Strombolian basalts refer to Francalanci et al (1989) and Wilson et al (2006). However Strombolian eruptions normally occur several times per hour from one or more of the active vents sited 150 m below the Pizzo Sopra la Fossa (Fig. 1). These explosions led to fallout of fresh lapilli or scoria. Samples of lapilli and scoria (see Fig. 12) collected on Stromboli belong to the black scoriaceous volcanic material normally erupted during Strombolian activity. Figure 12 shows a vesicular, black in color, glassy rock formed during eruptions, when decreasing pressure causes gas to «bubble out» of andesitic and basaltic magma. The black color is mostly due to its iron content.

Figure 11: Andesite from Stromboli (private collection of the author).

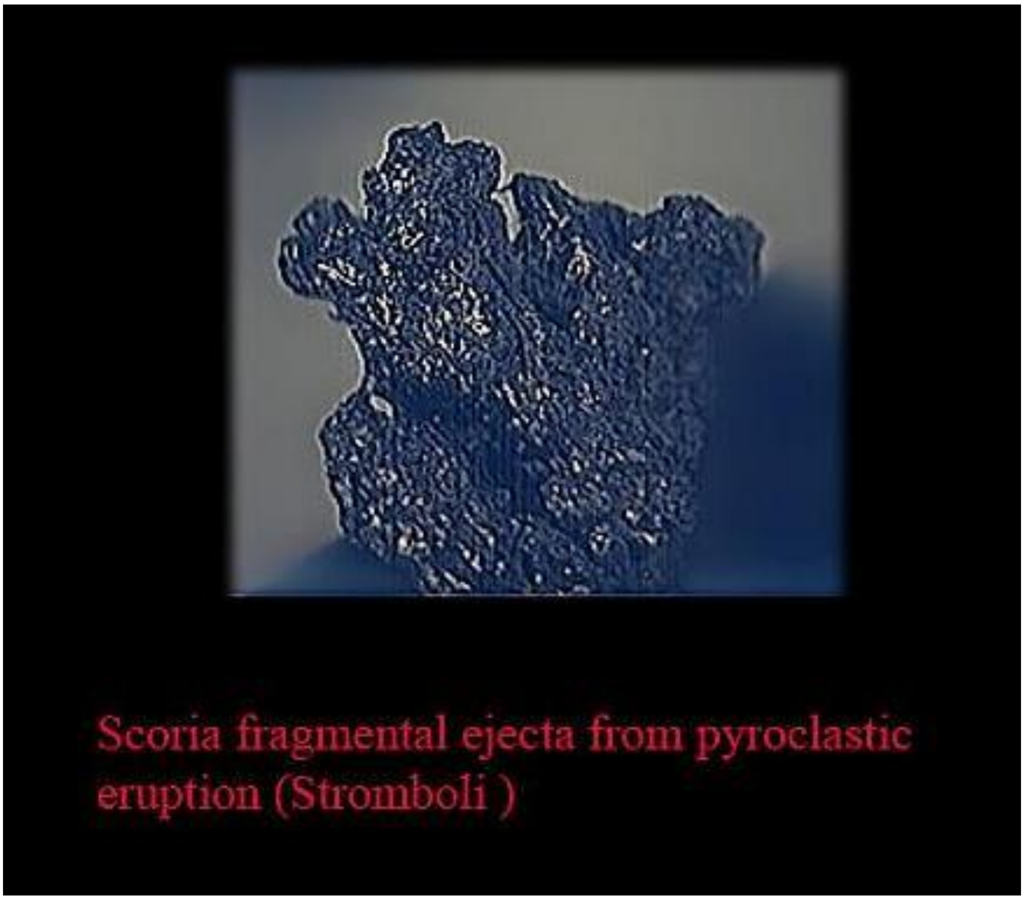

Figure 12: Scoria from a Strombolian eruption (private collection of the author).

As shown from volcanic material and petrologic analysis, the activity in Stromboli and nearby Vulcano island, is different from the material produced during the volcanic activity in the Lipari island, another Aeolian island, which contains craters and lava domes on a basement of submarine volcanic deposits.

The latest eruption in historic times, probably in 729 AD, at Monte Pilatus at the NE tip of the Lipari Island, formed obsidian lava flow and deposit of pumice (cfr. Figs. 13 and 14).

Figure 13: different eruption material from Lipari. Obsidian (private collection of the author).

Figure 14 a: The obsidian texture. The samples were collected in Lipari (private collection of the author).

Figure 14 b: Pumice. The samples were collected in Lipari (private collection of the author).

Stromboli has an activity characterized by the intermittent explosion or fountaining of lava from the vents, especially from crater 1 (the NE-crater) and crater 3 (the SW-crater), with scoria, lapilli and ash ejected within a very restricted area close to the vents (Fig. 15). Occasionally the volcano enters a period of more activity called a ‘paroxysm’. This is characterized by the ejection of the volcanic products outside the caldera rim and bombs can even land on the villages on the island. Bertagnini et al. (1999) reported emission of “golden pumice” when associated with paroxysmal explosive events.

Figure 15: A strombolian eruption image from Crater 1. Image taken by the author from Punta Labronzo.

The magma in a Strombolian eruption rises slowly in the vent, allowing bubbles to coalesce and separate from the melt, as they rise to the top of the magma column. Upon reaching the surface, the gas pocket disrupts the magma, throwing it out ballistically. The whole cycle repeats, with individual blasts separated by anything from a fraction of a second to hours (Fig. 16).

Two main possibilities have been proposed to explain the paroxysmal explosive events: changes in the volatile flux, or changes in the groundwater level. Recently it has been demonstrated that paroxysm is heralded by anomalous increases in sulphur degassing (Aiuppa & Federico, 2004) and CO_2 and H_2 degassing (Carapezza et al., 2004), strongly suggesting that the shift in the style of activity is mainly controlled by changes in the volatile flux.

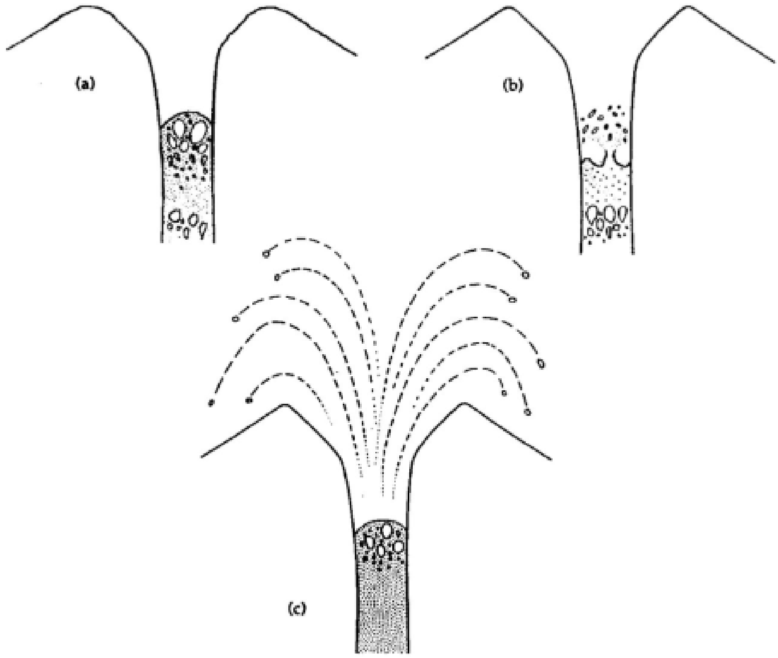

Figure 16: scheme of a Strombolian eruption.

Lunar Pyroclastic material

The explosive eruptions that formed the lunar dark mantle deposits have been likened to some types of terrestrial volcanic activity. Intermittently explosive or Vulcanian-style eruptions are likely to have produced the small pyroclastic deposits, with explosive decompression acting to remove a plug of lava within a conduit and to form an endogenic vent crater (Head and Wilson, 1979). On the other hand, in a Strombolian eruption explosive decompression occurs as the pressure is released and the magma and gas rise in an expanding column of erupting material. For the moon the particles will spread out over an area roughly six times larger on the Moon than they would for a similar eruption on Earth. Larger fragments will be deposited closest to the vent. A Strombolian eruption is consistent with the volatile coated spheres returned from the Apollo 17 landing site. Among the largest of the dark mantle deposits are Aristarchus plateau, Mare Humorum, South Mare Vaporum and Sulpicius Gallus deposits.

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