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Stevenson at Vulcano in the late 19th century: a Scottish mining venture in southern Europe

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ABSTRACT

This project seeks to recover and record the archaeological evidence associated with the extraction of sulfur (and perhaps other minerals as well) by James Stevenson, a Glasgow industrialist, from the volcanic island of Vulcano, Aeolian Islands, Italy, in the second half of the 19th century. This short preliminary report sets the scene by linking archival material with present conditions and by carrying out select mineralogical analyses of the type of the mineral resource Stevenson may have explored. New 3D digital recording tools (Structure-from-Motion photogrammetry) have been introduced to aid future multidisciplinary research. This is a long-term project which aims to examine a 19th-century Scottish mining venture in a southern European context and its legacy on the communities involved. It also aims to view Stevenson's activities in a diachronic framework, namely as an integral part of a tradition of minerals exploration in southern Italy from the Roman period or earlier.

INTRODUCTION

James 'Croesus' Stevenson (1822–1903) (Illus 1) was a Glasgow industrialist manufacturing sodium and potassium chromates for the dyeing and calico industries (Stevenson 2009: 162). Sulfur (as sulfuric acid) was a key ingredient in converting potassium chromate to potassium dichromate. At the time, it was usual for Glasgow industries to import sulfur from the Mediterranean (for example, from the Huelva district in southern Spain), and in the early 1870s Stevenson bought the sulfur-rich volcanic island of Vulcano in the Aeolian Islands, north of Sicily (Illus 2a, b). The previous owner was the Marquis Vito Nunziante, a Bourbon general who fought against Napoleon, who had obtained the rights to mine in Vulcano from the Bishopric of Lipari (Campostrini et al 2011: 20). Stevenson extracted sulfur but possibly other minerals as well. However, his operations on the island were short-lived because on 3 August 1888, the island's central volcano erupted and continued its activity for two years, causing considerable damage and halting works. Stevenson died in 1903 and his landholdings and mineral rights were sold to the Conti family of Lipari (Campostrini et al 2011: 21).

Stevenson was an astute businessman, a keen yachtsman and a philanthropist. In Vulcano he built (or adapted from existing buildings) the 'casa dell'Inglese' (Illus 1 and 5a), the Englishman being not himself but his foreman, Mr Narlian, who lived there with his family until the night of the eruption. There is a vivid account of their escape reported in *Nature* dated 1888 (Johnston-Lavis 1888). The house has since undergone many modifications but survives to this day (Illus 8b).

Stevenson never married. When he inherited his father's cotton fortune he was 47, single, handsome and rich. According to his family's biographer 'like many Scots, he was canny with his money, but could be generous to a fault … He would lavish hospitality on his relations, but was shy and retiring at the same time. In public life he would sometimes find himself in

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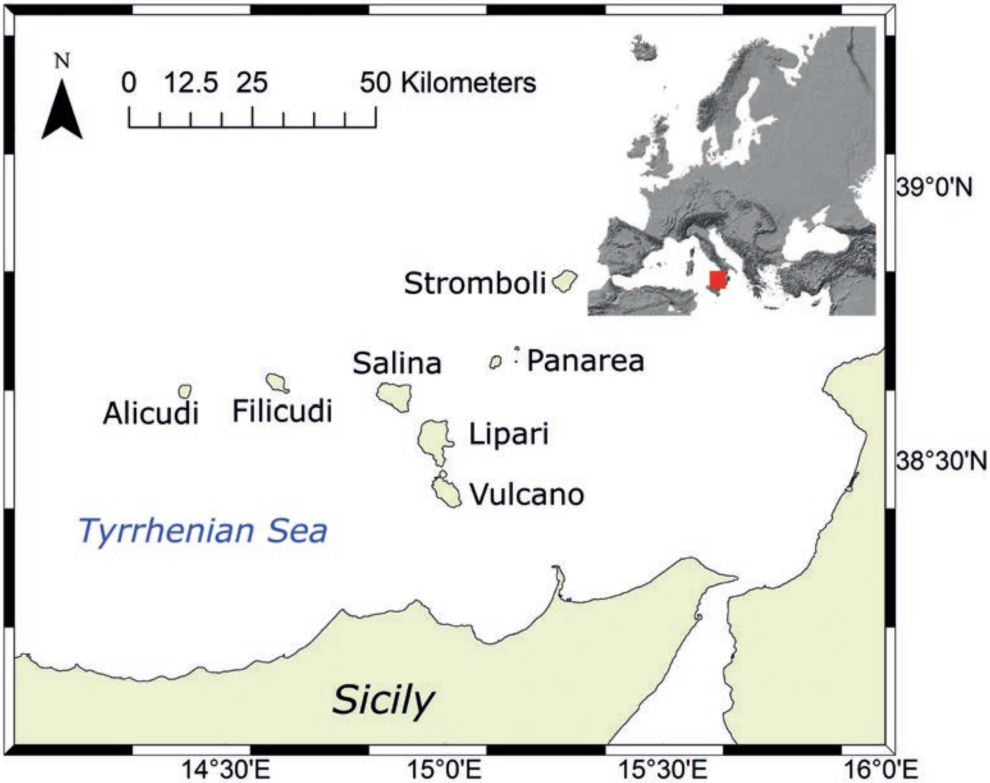
Illus 1 James Stevenson (1822–1903). View of the casa dell'Inglese from the north (dated 1980s), with the Faraglione in the foreground (to the left) and the La Fossa crater in the background. (Photo of the casa dell'Inglese reproduced with the kind permission of the estate of Stefano Finazzi; photo of Stevenson taken in the late 1800s and reproduced with the kind permission of Mr Gustavo Conti, photographer unknown)

the limelight – perhaps even courted it – but then, inexplicably, would shrink from it'. He was a 'hypochondriac' afraid to exert himself but in actual fact quite healthy (Stevenson 2009: 163–4). On his visits, Stevenson rarely stayed on the island, instead preferring to stay on board his yacht. It is probably safe to say that he was considered a bit of an eccentric by the locals, but his introduction of the cultivation of the malvasia grape is a tradition that continues to this day.

In 1879, Stevenson sponsored an excavation on Lipari in the area of the Contrada Diana (Murray 1886). The site, consisting of graves of the Hellenistic period (4th–3rd centuries BC), revealed many finds which Stevenson bequeathed to the Kelvingrove Museum, Glasgow (see Glasgow Museums Collections, The Lipari Collection, eg ID no. 1903.70.e; 1903.70.f). In addition to the Kelvingrove collection there is a small collection of figurines, lamps and vases also originally belonging to him, bought on sale from Sotheby's in 1944 and now in the Ashmolean Museum, Oxford (Gill & Vickers 1995: 223–6). The Sotheby's catalogue mentions that the artefacts 'were found by the staff of Mr. James Stevenson on the edge of the crater of the volcano on the island of Vulcano, one of the Lipari islands, which he purchased from the Italian Government in 1860', but their provenance has been disputed (Gill & Vickers 1995: 223). In addition to these finds, a well-known hoard of silver coins was also recovered on Vulcano and on Stevenson's property (Macdonald 1896). These two sets of finds, albeit not of secure provenance, are to this day the only reported archaeological finds on the island.

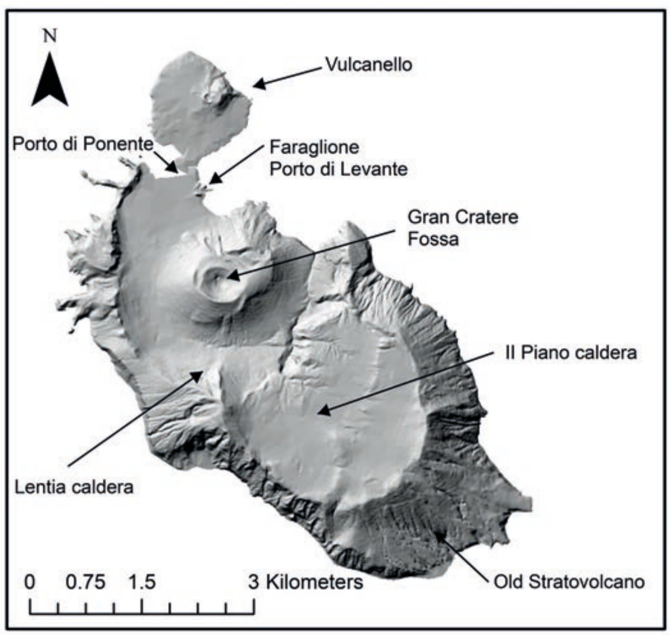
Although a considerable amount of information exists about James Stevenson, the public and the private man, as well as his collection of Liparian antiquities, relatively little is known about the nature and extent of his industrial operations at Vulcano between the 1870s and 1888. This is partly because the company's archives, either in Glasgow or in Lipari, are yet to be researched. It is almost certain that Stevenson relied on tried and tested practices for the recovery of sulfur and other minerals (alum), however, there is as yet no archaeological verification for any of these activities. Singer (1948: 79) mentions that in reference to the medieval period, there was evidence that Vulcano 'never passed out of action as a source of alum'. In the last part of the 15th century, several sources of alum were discovered or re-discovered in Italy, one



ILLUS 2a Aeolian Islands, Italy. Vulcano is the southernmost of the seven islands and closest to Sicily. © *The Vulcano Project*

of them being Vulcano (Singer 1948: 139). Extractive activities on the island continued well into the early part of the 19th century, under Nunziante's ownership and prior to Stevenson's arrival.

Archaeological research into these practices is of great interest because it is likely to shed light on similar practices during the Classical-Roman



ILLUS 2b Hillshaded terrain model of Vulcano with areas mentioned in the text. The areas of Stevenson's works (both extractive and workshops) focused on the Faraglione, Porto di Levante and in the Fossa. © *The Vulcano Project*

period. Extractive processes were already in place during that period, on Melos, Cyclades, Greece (Hall & Photos-Jones 2009; Photos-Jones & Hall 2014), and perhaps on Lipari too, since both islands were considered major alum and sulfur producers in antiquity (Pliny *Natural History* 35.50; 35.52). It is possible that the ancient sources, when referring to Lipari, may also have included Vulcano within its territory, given the islands' close proximity. Unravelling the different sources of the alum group minerals in the Tyrrhenian Sea, and their extraction and processing during the Roman period, is a separate research project currently underway by the authors and their team. Lipari has extensive deposits of kaolin associated with alunite known to have been worked in the Hellenistic and later periods (Bernabò Brea & Cavalier 1992; Christidis & Photos-Jones in prep).

ABOUT VULCANO IN ANTIQUITY

The Aeolian Islands are thought to have derived their name from their association with Aeolus, the keeper of winds (Homer *Odyssey* 10.1); they were also referred to as 'Lipari Islands' (Λιπαραίας νήσους) (Polybius *Histories* 1.25.4) but also as *Hephaistiadai* on account of their association with Hephaistos (Pliny *Natural History* 3.8.92). It was generally accepted that they consisted of a cluster of seven main islands to include Stromboli, Panarea, Salina, Vulcano, Filicudi, Alicudi as well as the rocky outcrop Bazilluzzo (Illus 2a).

Throughout antiquity, Vulcano was called *Hiera* or *Hiera Hephaistou* (Ἱερά Ἡφαίστου) meaning sacred to the god Hephaistos, but Strabo calls it *Thermessa* (Θέρμεσσα). Amongst the earliest references to Vulcano is one recorded by Aristotle (*Meteorologica* 2.8) in the 4th century BC, where he tells us that 'in the island of Hiera the earth swelled up with a loud noise, and rose into the form of a considerable hillock, which at length burst and sent forth not only vapour, but hot cinders and ashes in such quantities that they covered the whole city of Lipara, and some of them were carried even to the coast of Italy'. In the 1st century BC, Strabo (Harry 2002), describing a passage in Posidonius (fr 227) regarding an event in the previous century, wrote that 'the sea between Hiera and Euonymus was seen raised to an enormous height, and by a sustained blast remained puffed up for a considerable time, and then subsided; and when those who were bold enough to sail up to it saw dead fish driven by the current, and being stricken ill because of the heat and stench, they took flight; … and many days later mud was seen forming on the surface of the sea, and in many places flames, smoke, and murky fire broke forth, but later the scum hardened and became as hard as mill-stone; and the governor of Sicily, Titus Flamininus, reported the event to the Senate, and the Senate sent a deputation to offer propitiatory sacrifices, both in the islet and in Liparae, to the gods both of the underworld and of the sea' (for translation of Posidonius passage, see Harry 2002). A full list of eruptions from 300 BC to 1892 is given by Campostrini et al (2011: 308), while the documented earthquakes and volcanic eruptions in the Greco-Roman world are presented by Harry (2002).

The volcanic history of the island has been well studied (De Astis et al 2013). For the purposes of this short report, Illus 2b gives the names of the five different calderas and the periods of their formation. The caldera of interest to the present discussion is La Fossa or Gran Caldera. The Stratovolcano is the oldest part of the island (120–100kya) followed by the Il Piano caldera (*c* 100kya), the Lentia caldera (24–15kya), the La Fossa caldera (*c* 6kya) with the most recent eruption in 1888–90, and finally Vulcanello. Originally Vulcanello was formed as an islet in 183 BC, but lava flowing from an eruption in 1550 joined the islet and Vulcano with an isthmus. In antiquity, it was thought that most of the islands, with the exception of Lipari, were uninhabited and it was Liparians who were cultivating the smaller islands, namely, *Strongyle* (Stromboli), *Didyme* (Salina) and *Hiera* (Vulcano) (Thucydides *History* 3.88). This may partly explain why there is little archaeological evidence recovered so far from Vulcano (Bernabò Brea & Cavalier 1992; Giustolisi 1995).

ILLUS 3a View of Porto di Levante, looking north towards Lipari, taken from the crater, with Vulcanello in the foreground and Lipari in the background, *c* 1950s. (Reproduced with the kind permission of Mr Marco Spisso)

ILLUS 3b Same view taken in November 2016. The construction of the pier took place in the 1980s. The two 'hillocks' on either side of the pier, one barren (to the north of the pier) and the other covered in vegetation (to the south of the pier) correspond to the solfatara and mudpool (*pozza di fanghi*) and to the cave of alum (*cave di alume*) respectively. © *The Vulcano Project*

ILLUS 4a Archduke Louis Salvator's 1890s illustration of the viaduct leading to the crater with path carved into the volcano slope

ILLUS 4b Same area photographed in November 2016. There are no visible remnants of the viaduct today, and any installations located within the crater were destroyed in the course of continuous eruptions between August 1888 and 1890. The lines denote the present-day path to the crater's rim. © *The Vulcano Project*

Unravelling Stevenson's operations requires a two-pronged approach, the first targeting installations, the second materials and practices. The island, and particularly the area between the two bays (Porto di Ponente and Porto di Levante) (Illus 2b) where Stevenson focused his activities, has undergone major development over the last 20 to 30 years, as seen in Illus 3a and 3b. Locating his installations (workshops and storage areas) amidst the sprawling tourist development is not straightforward. However, although the eruption of August 1888 obliterated much of the evidence for installations within the Fossa crater, as seen in contemporary illustrations, or of the viaduct that connected the port with the Fossa crater (Illus 4a, b), it caused severe but not irreparable damage to structures in the Porto di Levante. Indeed, in photos of 1922 (Illus 5b) a number of what must have been workshops appear restored as 'farmhouses'. Some of these may survive to this day as tourist shops. In this paper we juxtapose archival material, illustrations and photographs with photographs taken in November 2016, the time of our survey. We focus on the same areas and have taken photographs from the same viewpoints. This allows a first appraisal of the anthropogenic changes introduced in the landscape. Environmental changes deriving from the island's active volcanism are also highly relevant.

ILLUS 5a Photograph taken after the eruption showing Stevenson's house still standing. The rampart-style décor along the roof present in later photos (Illus 1) is not visible here

ILLUS 5b Detail of the state of preservation of the 'workshops' (some roofless, others abandoned but a few restored and referred to as 'farmhouses'). Photograph dated 1922, detail from photograph by L Sicardi, published in Giustolisi 1995, fig 48

METHODS

This is a multi-disciplinary project following in the footsteps of geo-archaeological work in the Aegean Islands (Photos-Jones & Hall 2011, 2014), employing a number of scientific techniques and aiming to elucidate the minerals and 'pharmaceuticals' industry of Greco-Roman antiquity. In this report our method is based on two tools: first, Structure-from-Motion (SfM)

TABLE 1
Results of X-ray diffraction analyses of select geological samples from the Faraglione and the Fossa crater. Composition is weight %. 'X' denotes presence of amorphous matter which has not been quantified

Sample no.	*General description*	*Locality of sampling*	*Alunite*	*Alunogen*	*Alum-(K)*	*Gypsum*
1400.3	Sulfur-rich therapeutic mud	Mud collected from the lip around the mudpool, Faraglione	20.2			15.4
1444	Sulfur-rich therapeutic mud	Stable suspension of mud from within the mudpool, Faraglione	23			
1433	Sulfur-Fossa crater	Sulfur-rich sample from lip of Fossa crater	2.2			
1438	Sulfur-Faraglione	Sulfur crystals collected around vent, higher ground overlooking mudpool, Faraglione				
1415	Alum-related, Faraglione	Alunite-rich clay-like mud from higher ground overlooking mudpool, Faraglione	75.2	13.9		10.9
1442a	Alum-related, Faraglione	Alunogen with Sulfur within collapsed tunnel, from higher ground overlooking port (opposite direction to the mudpool), Faraglione	54.3	38.1	1	1.5
1465	Alum-related, Faraglione	*Cave di alume*, Faraglione		4.1	0.9	

photogrammetry for the accurate recording of the features of interest, and second, mineralogical investigation for a preliminary assessment of the type of sulfur and other deposits which would have been available to Stevenson for exploitation at the two areas where he is known to have worked, namely the area of the Faraglione, and within the Fossa crater. The Faraglione consists of a field of fumaroles (called here solfataras) which are vents emitting steam containing gases like carbon dioxide and hydrogen sulphide; fumarolic activity is integrally connected with the island's active volcanism. Fumaroles are sources of both sulfur and alum group minerals and exist in the area of the Faraglione as well as within the Fossa crater (Illus 7a and b). The Faraglione today, but not in Stevenson's time, contains a mudpool (*pozza dei fanghi*) used for therapeutic purposes (Illus 9a). Our minerals sampling strategy was not systematic, but rather selective, and the information provided here is indicative rather than conclusive. 3D capture technologies provide 3D models for exploration in a virtual archive. These will act

α-Sulfur	*Quartz*	*Tamarugite*	*Voltaite*	*Pickeringite*	*Halotrichite*	*Magnesioaubertite*	*Mohrite*	*Halite*	*Cristobalite*	*Anatase*	*amorphous matter*
64.4											
74.1	2.3										
59.8	10.6								25.3	2.1	X
99.5	0.5										X
1.2		4.3	0.5								
		18.6		36.6	29.4	9.6	0.8	0.6			X

as a contemporary baseline and allow for further investigation into the areas of interest in the future.

SFM PHOTOGRAMMETRY

Significant advances in remote sensing and digital imaging technologies, for example, close-range Structure-from-Motion (SfM) photogrammetry, have led to their increasing use for accurate recording and sophisticated modelling in archaeology and with particular reference to caves (González-Aguilera et al 2009; Burens et al 2014). SfM is used to create 3D models of an artefact or a feature from overlapping photographs (2D) taken systematically from many locations and orientations. The aim is to reconstruct accurately and in high resolution the feature or object of interest. In this study, SfM was used extensively to create a 3D model of a natural feature (alum cave), installation remains (furnace wall) and areas of mineralogical interest (hydrothermal vents emitting sulfur and alum group minerals). Photo stills are shown in illustrations throughout this text, but the digital 'tours' around the features can be viewed in the following links: https://sketchfab.com/models/7d9c5bcf95b948ae95091cd36a502d4d for the alum cave; and https://sketchfab.com/models/eaa46cf3f8824038a1ec2cc3859aba8f for a detail of the Faraglione solfatara. The digital reconstruction of aspects of cultural heritage facilitates the thorough investigation of how humans interact with their environment; therefore, it constitutes a powerful tool for study and analysis.

MINERALOGY

A large number of samples were collected from many localities but only a select number were analysed and are presented here. The mineralogical composition of all samples was determined with X-ray diffraction (XRD) at the School of Mineral Resources Engineering, Technical University of Crete, on a Bruker D8 Advance Diffractometer equipped with a Lynx Eye strip silicon detector, using Ni-filtered CuKα radiation (35kV, 35mA). Data were collected in the 2θ range 3–70°, 2θ with a step size of 0.02° and counting time of 1 second per strip step (total time 63.6 seconds per step). The XRD traces were analysed and interpreted with the Diffrac Plus software package from Bruker and the Powder Diffraction Files (PDF). The quantitative analysis was performed on random powder samples (side-loading mounting) by the Rietveld method using the BMGN code (Autoquan© software package v. 2.8).

RESULTS

MINERALOGY

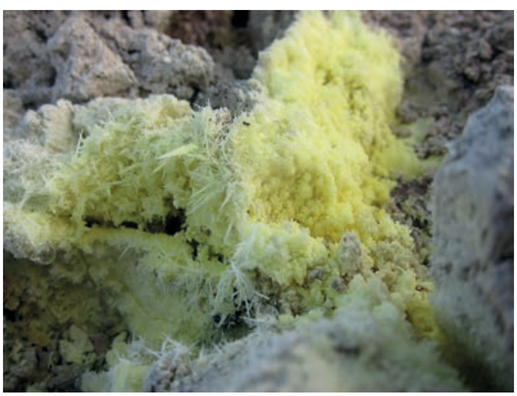
Samples from different sampling locations display different mineralogy. Table 1 gives a quantitative assessment of the composition of each. Table 2 gives the chemical formula for each of the minerals in Table 1. The quantitative analyses pertain to the crystalline phases only. Several samples contain amorphous matter, which was neither quantified nor mineralogically characterised, being 'opaque' to X-ray diffraction analysis.

TABLE 2
Chemical formulas for all minerals discussed in Table 1 and in the text

Alum-(K)	$KAl(SO_4)_2 \cdot 12H_2O$
Alunite	$KAl_3(SO_4)_2(OH)_6$
Alunogen	$Al_2(SO_4)_3 \cdot 17H_2O$
Anatase	TiO_2
Cristobalite	SiO_2
Gypsum	$CaSO_4 \cdot 2H_2O$
Halite	$NaCl$
Halotrichite	$FeAl_2(SO_4)_4 \cdot 22H_2O$
Magnesio-aubertite	$(Mg,Cu)Al(SO_4)_2Cl \cdot 14H_2O$
Mohrite	$(NH_4)_2Fe(SO_4)_2 \cdot 6H_2O$
Pickeringite	$MgAl_2(SO_4)_4 \cdot 22H_2O$
Quartz	SiO_2
Sulfur	S
Tamarugite	$NaAl(SO_4)_2 \cdot 6H_2O$
Voltaite	$K_2Fe^{2+}_5(Fe^{3+}Al)_4(SO_4)_{12} \cdot 18H_2O$

Illus 6a Fine crystals of pickeringite, the magnesium aluminium sulphate hydrate from the area of the Faraglione solfatara and in the vicinity of the sulfur emitting vent. © *The Vulcano Project*

The sediments within and in the vicinity of the mudpool (Illus 9a) consist principally of α-sulfur with minor alunite and, in places, minor alunogen and gypsum and accessory quartz. Amorphous matter is also locally present. The samples collected away from the pool are richer in alunite and alunogen and are essentially free of α-sulfur, whereas samples rich in alum salts contain alunogen, alum-(K) and tamarugite. The sample collected from the *cave di alume* (alum cave) has distinct mineralogy consisting entirely of alum salts such as alunogen, pickeringite (see Illus 6a), magnesio-aubertite (a rare mineral which has Vulcano as its type locality) tamarugite



Illus 6b Sulfur needles growing around the vent at Faraglione; spot locality for Sample 1438. © *The Vulcano Project*

and mohrite (Table 2). Samples associated with fumaroles in the vicinity of the mudpool have similar mineralogy except for the fact that they contain various amounts of kaolinite and amorphous matter. Finally, the samples collected from the solfatara within the Fossa crater consist essentially of α-sulfur and SiO_2-polymorphs (quartz and cristobalite), whereas the fine-grained, clay-like samples collected from the path to the La Fossa crater (Illus 4b) consist entirely of primary minerals, namely basic plagioclase (labradorite) and augite, with minor goethite and accessory ilmenite. The latter sample is free of secondary minerals associated with the solfatara activity of the island.

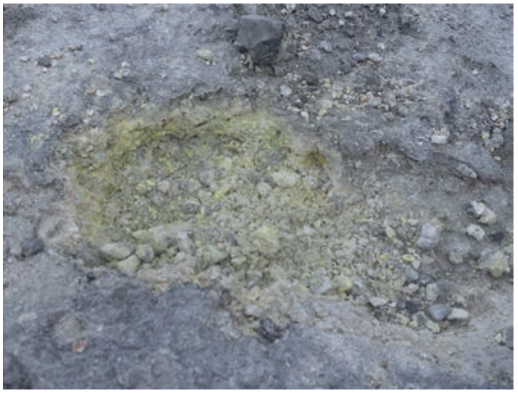
SULFUR EXTRACTION AT THE CRATER AND THE FARAGLIONE SOLFATARA

Sulfur extraction from within the Fossa crater was already taking place when the painter J Houel visited Sicily and the Aeolian islands between 1776 and 1779 (Hermitage Museum, Inventory No. OP-4149) (Illus 8a). Illus 7a shows the intense degassing activity within the crater. Illus 6b shows a close-up of acicular yellow crystals of sulfur, near a degassing vent at the Faraglione, Porto di Levante. Illus 7b shows a close-up of the collection spot for Sample 1433 (Table 1) from the rim of the crater, consisting of sulfur and other minerals to include cristoballite but also alunite. This is the type of ‘ore’ which would have been charged in the large *calcarone* furnaces described below.

THE AREA OF THE FARAGLIONE

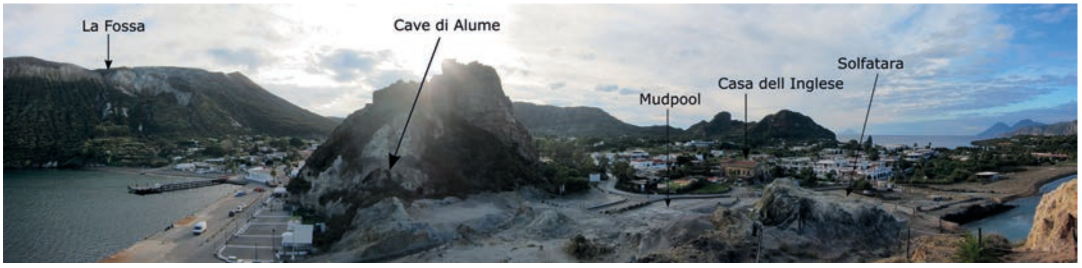
In addition to the crater, Stevenson’s activities also focused on the area of the Porto di Levante (Illus 8b). The Faraglione solfatara consists of an open area overlooking and incorporating the mudpool (Illus 9a), popular in the summer with bathers seeking treatment, and the adjacent beach with its underwater hot springs. It is separated from the cave of alum by the tarmac road which was opened only in the 1980s. Although the Faraglione solfatara gives the appearance of a solid tuff outcrop, it actually consists largely

Illus 7a Crater's rim, degassing vents



Illus 7b Close up of spot locality for Sample 1433, associated with the vents shown in Illus 7a. © *The Vulcano Project*

Illus 8a View of the crater, taken in December 2016. Houel painted the same view when he visited the islands in the late 1770s. Ascent to the rim of the crater is not difficult, and as Smyth (1824) noted 'even an invalid can climb it'. The view is to the north with Lipari in the foreground and Salina's twin peaks showing in the background. Despite the relative ease of the climb, the active fumaroles create an intensely toxic environment (with CO and H_2S emissions) and descent into the crater is prohibited. © *The Vulcano Project*



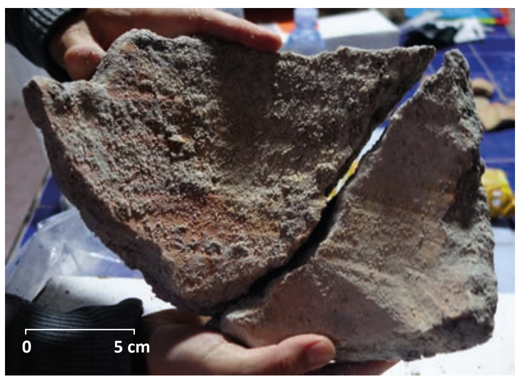
Illus 8b Panoramic view (December 2016) of the area of the Faraglione, Porto di Levante. View towards the south. Tunnel entrances in the cave of alum are visible but the port side has been largely re-landscaped. The same applies to the area of the solfatara. © *The Vulcano Project*

ILLUS 9a View of the Faraglione with mudpool and active fumaroles in the foreground. Wooden planks are laid over the hot soils and the area surrounding the mudpool consists largely of natural and secondary deposits. Only archaeological excavation can clarify the extent of each. Sherds of largely undiagnostic pottery have been removed from within secondary deposits. © *The Vulcano Project*

of unconsolidated waste material deriving from multi-period extractive works and sediments resulting from the weathering of the tuff by the local geothermal field (temperatures at the vents measured 60–75°C).

SULFUR PROCESSING: SULFUR MELTING IN CALCARONE-TYPE FURNACES ON THE VOLCANO'S NORTHERN SLOPES

Three sulfur melting furnaces of the *calcarone* type were observed and photographed and one of them was digitally scanned (Illus 10a, b). *Calcarone* furnaces (diam = 10–20m), a larger diameter version of the *calcarella* furnace (diam = 2–5m), were used in Sicily in the 19th century. They became the standard design in other sulfur-producing parts of the Mediterannean – such as Melos (Photos-Jones & Hall 2014). Sulfur



ILLUS 9b Large fragments of large container (pithos?) in a very fragile state of preservation embedded within the hot sediments in the area to the east of the mudpool. © *The Vulcano Project*

Illus 9c Fragments of rims and undecorated sherds, of unspecified date, retrieved from the same sediments in the Faraglione and overlooking the mudpool. © *The Vulcano Project*

has a low melting point (*c* 113°C) and so when sulfur-rich ore is charged in those furnaces, upon ignition it begins to melt and separates from the surrounding rock by trickling out of the front arch. Sulfur with a composition similar to that of Sample 1438 (Illus 7b and Table 1) would be charged within and stacked in a pile up to a height of *c* 2m. The fuel would be provided by the sulfur itself, which self-ignites. One smelting 'campaign' would last a few weeks, even months, the whole process being rather wasteful on account of the sulfur lost in the air as sulfur dioxide. Molten sulfur would be collected into wooden moulds and loaded onto mules for transport to the port (Kutney 2007: 47).

In many respects, earlier (medieval or earlier) sulfur-melting practices contained within ceramic vessels were much more efficient as shown in the 16th-century illustration by Agricola (Hoover & Hoover 1950: 579) (Illus 9f). However, the scale of production was much more limited and commensurate with laboratory-, rather than

Illus 9d Sections of two clay tubes with a slight curvature and retrieved from the same sediments in the Faraglione as the sherds in Illus 9c, in the area to the east of the mudpool. © The *Vulcano Project*

ILLUS 9e Interior of clay tubes with thick layers of incrustation. © *The Vulcano Project*

ILLUS 9f Illustration from Agricola (*De Re Metallica*) of sulfur ore melting while heated over a hearth in closed ceramic pots (A), the molten sulfur being led via clay pipes into vessel B. This laboratory-based facility, although probably inadequate for large-scale production, would be much more resource efficient than heating in the *calcarone* furnaces. After Hoover and Hoover 1950.

Illus 10a Upstanding remains of the wall of one of three upstanding *calcarone* furnaces, consisting of external and internal stone masonry wall in-filled with rubble. The interior wall is lined with plaster. © The *Vulcano Project*

industrial-, scale activities. Nevertheless, later developments in furnace construction, which replaced the vastly inefficient and polluting *calcarone* furnaces, arose out of this Agricola laboratory arrangement. In Illus 9f, two heated ceramic vessels (A) feed their molten sulfur via clay pipes into a third vessel (B). The recovery of clay tubes showing a slight curvature within the secondary deposits of the Faraglione sediments (Illus 9d–e) potentially points to extractive processes happening on site before the 19th century. It is for this reason that the secondary deposits at the Faraglione certainly merit further investigation, both on account of these clay tubes, and the pottery on site (Illus 9b–e).

Illus 10b 3D photogrammetric model of part of the front wall giving great detail of the construction materials and ore waste embedded within. © *The Vulcano Project*

THE CAVE OF ALUM

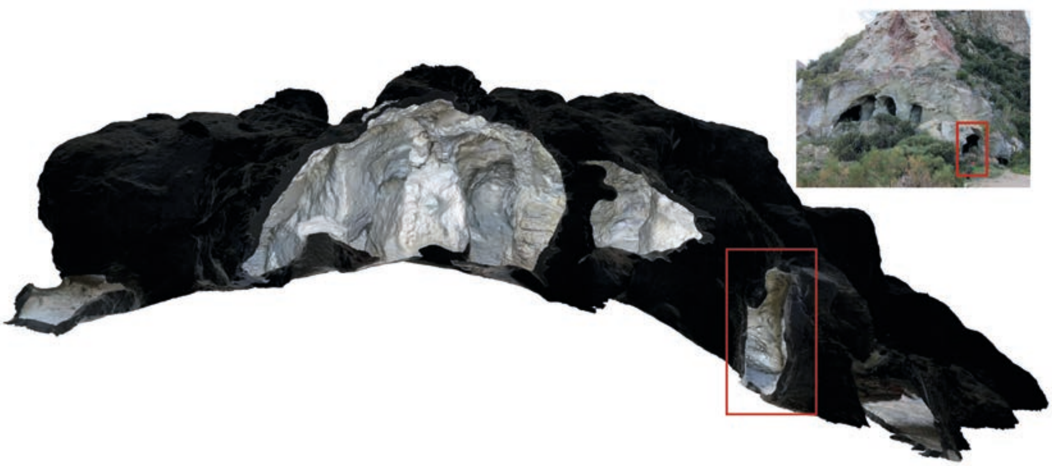
The alum mine overlooking the Porto di Levante (Illus 8b) was the site of the extraction of alum in the 19th century and possibly also the early 20th century.

ILLUS 11a Archduke Louis Salvator's 1890s illustration of the interior of the alum cave (*cave di alume*). The seated figure in the illustration gives a sense of the cave's size.

ILLUS 11b Same spot within the cave photographed on 30 November 2016. © *The Vulcano Project*

ILLUS 11c View of a sector of the alum cave with collapsed pillars. There are no visible vents within the cave and most of the alum group minerals must have formed in the past. Still from a sketchfab file mentioned in the text. © The *Vulcano Project*

Analysis of a single sample (Sample 1465, Table 1) reflects the veritable range of alum group minerals found within the cave and makes Vulcano a type location for rare minerals like magnesio-aubertite – a copper magnesium aluminium sulphate/chloride – also found within this sample (Campostrini et al 2011: 313). Large boulders of alum can be seen currently lying on the floor of its large cavernous chambers. The Archduke Louis Salvator's illustration (Salvator 1893) (Illus 11a), drawn soon after the volcanic eruption of 1888, gives an idea of the scale of the exploitation, which most likely took place in Stevenson's time, but perhaps later as well.



ILLUS 11d Close-up of entrance to the alum cave. Still from the sketchfab file mentioned in the text. © *The Vulcano Project*

The alum cave mineralisation presents a contrasting picture to that of the solfatara, on account of the presence of alunite and alunogen (Samples 1442a and 1415, Table 1, from the solfatara) and the lack of degassing vents within the cave. Assuming that the alum cave generated principally alum group minerals and that it was indeed exploited by Stevenson, the question arises: how was that alum processed? Alunite associated with sulfur (as in the case of Sample 1433 from the crater) would be charged in the *calcarone* furnaces together with sulfur but would be removed as ‘gangue’ or waste and it would then be discarded. Samples 1442a and 1415 have between them a total of 90–5% alunite and alunogen, and if that type of ‘ore’ were available it would constitute a rich alum resource. Singer (1948: 56) wrote that ‘roche alum … (or) Vulcano alum, is … gently calcined in a closed vessel on a moderate fire for one hour when it is found fused and hard like ice. Later it will fall into a white powder (if left on the fire). Its action is most useful in dyeing cloth.’ The last statement refers to alum as a mordant, its main application from antiquity to well into the 19th century. Singer’s description provides an insight into Stevenson’s potential practices, however, these will need to be corroborated by archaeological evidence. As already mentioned, the 3D model for the alum cave can be viewed in the following link: https://sketchfab.com/models/7d9c5bcf95b948ae95091cd36a502d4d.

CONCLUSIONS

The first exploratory season of work on Vulcano aimed to test the method by which to assess and record Stevenson’s years on the island from the perspective of the extant material culture. At this early stage it was important to implement a state-of-the-art method of digital recording on account of the need to record features (often precarious, like cave walls, or dynamic, like the solfatara) deriving from both the natural landscape (manifestations of volcanic activity like degassing vents and hot springs) and the cultural landscape (buildings, installations and artefacts). Structure-from-Motion (SfM) photogrammetry was deemed to be the way forward and in the event it has been successful. The recording of the interior of the cave of alum, which is presently inaccessible to the public, constitutes a rich digital resource, while the ability to home in and examine at leisure the minerals forming around a fumarole vent is an invaluable tool.

At this preliminary stage of the investigation, only parts of the late 19th-century industrial narrative have been revealed. Stevenson’s activities have been divided, for the purpose of closer scrutiny, into two distinct areas of research, alum and sulfur, although it is almost certain that their paths intertwined. At present, both in terms of material culture as well as natural resource, sulfur is the more archaeologically visible mineral: there are the ceramic tubes associated with sulfur ‘distillation’ (Illus 9d–e) and also the remains of the *calcarone* furnaces (Illus 10a–b) on the volcano’s northern slope, overlooking the Porto di Levante. It is not possible to ascertain the relative chronology between practices relating to the *calcarone* and those involving ceramic tubes, but the *calcarone* must certainly post-date the post-medieval practice of distilling sulfur within ceramic containers (Illus 9f). It is also not certain to what extent Stevenson made use of the *calcarone* and whether these furnaces (all three or any one of the three) were built by him or date to the early 20th century.

Regarding the natural resource, sulfur, this would have been derived primarily from the crater, as the now defunct bridge (Illus 4a) suggests, and the painting by Houel of installations within the crater imply. Mineralogically, the Fossa crater sulfur is rich in quartz and cristoballite, while that of the Faraglione, presently concentrating around vents, consists primarily of near-pure sulfur crystals in small quantities which can only be of limited economic value (Table 1). It is also not clear how much of the Faraglione mound overlooking the mudpool has been physically removed as a result of Stevenson’s activities. It is almost certain that Stevenson’s extractions were carried out in both areas.

The alum narrative is presently more opaque. The natural resource is integrally associated with sulfur (Table 1), as can be seen in samples collected in the area around the mudpool. In fact, the therapeutic mud from the pool's floor is a mixture of alunite and sulfur. It is likely that Stevenson extracted his alum from the cave of alum but how he went about processing it remains to be clarified. Future seasons of work will undertake a closer look at the upstanding workshop installations, presently operating as tourists' shops selling books, clothes and island souvenirs, for evidence of remnants of hearths.

Stevenson's activities on the island were short-lived and appear to have formed part of a minerals extraction tradition well embedded within the island's history. Thus, from an industry perspective, and at this early stage of investigation, it seems more a case of 'old industry – new (eccentric) owner' rather than the reverse. Yet there are currently many lacunae in our understanding of Stevenson's, or more precisely Narlian's, activities on the island, and how he ran his day-to-day business. On the other hand, Stevenson's alleged attempt to tap the local geothermal field by importing heavy machinery from Liverpool (Stevenson 2009: 243) may reveal attempts at innovation commensurate with his eccentric character and identity as a prominent Scottish industrialist in the 19th century.

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