KARL VON SCHERZER

NARRATIVE OF THE CIRCUMNAVIGATION OF THE GLOBE BY THE AUSTRIAN FRIGATE NOVARA

Karl von Scherzer

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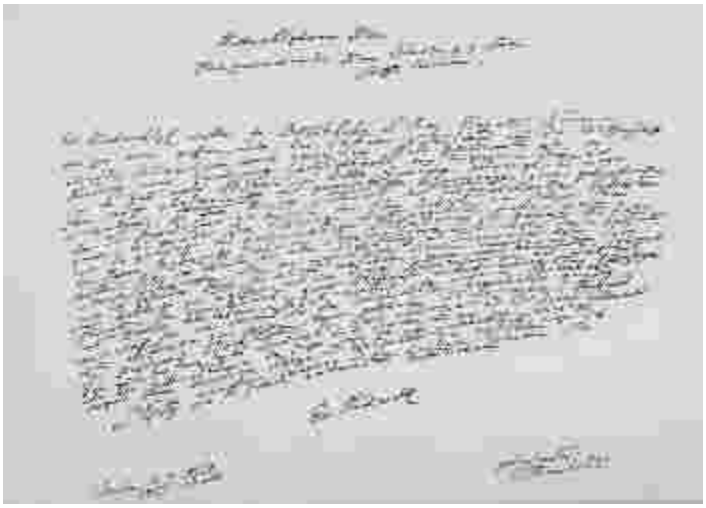

LETTER.

Sr. Hochwohlgeboren
dem Herrn Oberst von Wüllerstorf,
kais. kön. Linienschiffs-Capitän,
Befehlshaber S. Maj. Fregatte Novara,
Ritter hoher Orden &c. &c. &c.
in
Triest.

Hochwohlgeborener Herr,

Hochzuverehrender Herr Oberst, k. k.
Linien-Schiffs-Capitän.

Ew. Hochwohlgeb. wollen, als Befehlshaber Sr. Maj. Fregatte Novara, die zu einem großen, edeln, das deutsche Vaterland und die Wissenschaft ehrenden Unternehmen durch kaiserliche Huld bestimmt ist, den Ausdruck meiner Verehrung nachsichtsvoll empfangen,

indem ich, von der Zeit naher Abfahrt in halber Genesung bedrängt, es wage, Ihnen einige *physikalische* und *geognostische Erinnerungen* ganz gehorsamst vorzulegen, von denen Einiges vielleicht den ausgezeichneten Gelehrten, die die Expedition zu begleiten das Glück haben, von Nuzen sein kann. Ich würde dies Wenige nicht angeboten haben, wenn eine so genädige und liebenswürdige Aufforderung Sr. kaiserl. Hoheit des Herrn Erzherzogs Ferdinand Maximilian mich nicht dazu bestimmt hätte. Was ich Nautisches über Richtung und Temperatur der Meeresströhmungen, über die magnetischen Curven eingeflochten habe, muß ich besonders *Ihrer* Nachsicht empfehlen. Wenn man erinnert, scheint man belehren zu wollen, und von dieser Anmaßung bin ich weit entfernt. Da kein Entwurf, keine Abschrift meiner, wenigstens fleißigen, mit Zahlen überladenen Arbeit existirt, so wäre es vielleicht vorsichtig, sie von Jemand, der der behandelten Gegenstände kundig ist, abschreiben zu lassen. Meine gelehrten und mir lieben Freunde Dr. Ferdinand Hochstetter, Dr. Karl Scherzer und Dr. Robert Lallemant, der mich bei seiner letzten Durchreise durch Berlin, um mir sein wichtiges Werk über das Gelbe Fieber in der Tropenzone zu geben, verfehlt hat, wage ich dringend Ihrem besonderen Schuze und Wohlwollen zu empfehlen.

Mit der innigsten Verehrung und den heißesten Wünschen für den Erfolg eines so schön vorbereiteten Unternehmens

Ew. Hochwohlgeboren

gehorsamster

Al. Humboldt.

Berlin, den 7. April
1857 Nachts.

PHYSICAL AND GEOGNOSTIC SUGGESTIONS

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BY
ALEXANDER VON HUMBOLDT.

In compliance with the gracious invitation which H.I.H. the Archduke Ferdinand Maximilian was pleased to address to me from Trieste (December 12th, 1856), and as yet barely recovered from an indisposition, I jot down these hasty notes, without presuming to give definite instructions, such as those I drew up, conjointly with M. Arago, for the guidance of the French expeditions, or for Lord Minto, then First Lord of the Admiralty, on the occasion of the Antarctic Voyage of Discovery of Sir James Ross (1840–43). The following pages consist simply of hints which may possibly prove serviceable to the distinguished and highly informed gentlemen, who have the good fortune to sail on board the Imperial Frigate, *Novara*, under the command of Commodore von Wüllerstorf. With two of these savans, Dr. Ferdinand Hochstetter and Dr. Karl Scherzer, I have had the pleasure, here in Berlin, to agree verbally on various subjects.

As I do not exactly know what course it is intended the *Novara* shall follow in navigating the Atlantic, nor in what meridian it is proposed to cross the Equator, (in conformity with the sound and useful directions of my friend Lieut. Maury, of Washington), on her voyage to Rio de Janeiro, nor how near she shall keep to Cape San Roque and Fernando de Noronha, I must content myself with inviting the

attention of the voyagers in a general way to the temperature of the sea, as also to the variations and aberrations of the magnetic curves, and their currents.

A lower degree of temperature is usually observed W. of the Canaries, and Cape Verde Islands, commencing with the Salvages, the thermometer indicating as low as 72°·7 Fahr. This has been already ascertained by Mr. Charles Deville, in his chart of temperature on the voyage "aux Antilles, à Ténériffe et à Fogo." I consider this diminution of temperature results from the North Guinea current, bringing with it cold water from the north southwards as far as the Bight of Biafra and the River Gaboon, at which point it is encountered by an opposite current flowing northwards along the south-western coast of Africa from Loando and Congo.

In 1825, Captain Duperrey had accurately laid down the point of intersection of the magnetic, with the terrestrial equator. In 1837, we learned from Sabine's investigations of magnetic inclination near the Island of St. Thomas (on the Equator, adjoining the above portion of the coast of Africa), that this point of intersection had already shifted four degrees to the westward. A period of twenty years having elapsed since Sabine's expedition for determining observations with the pendulum, it would be most desirable that fresh investigations should be made in that neighbourhood, for the purpose of verifying the secular changes of all magnetic curves, especially with regard to their variation. In 1840, the line of no declination in America began 9° 30′ E. of South Georgia, whence it ran to the S.E. coast of Brazil, near Cape Frio, thus traversing the mainland of South America only between the latter point and the parallel of 0° 36′ S., when it leaves the continent a little to the east of Gran Parà, near Cape Tigioca, cutting the

terrestrial equator again, but in 50° 6′ W. According to Bache's Map of Equal Magnetic Declination, it reaches the coast of North America near Cape Fear, to the south-west of Cape Lookout. This line, along which the magnetic declination is *nil*, extends to a point in Lake Erie, 2° 40′ W. of Toronto, where the declination is already 1° 27′ W.[2]

It is evident from the observations of Captains Beechey and Findley, and still more particularly from those of the French Captain Kerhallet, that the remarkable subdivision of the main equinoctial current, flowing from east to west into two branches, one directed to the N.W., the other to the S.S.W., commences at a considerable distance from the Capes of St. Roque and St. Augustin. This bifurcation has always, and with good reason, been ascribed to the protruding convexity of the South American continent at these two promontories. It would be an important step gained in verifying the theory of currents, could the precise distance be ascertained by chronometer. It is apparently like an "*actio in distans*," probably a phenomenon of what is known as "packing." As the frigate, on leaving Rio de Janeiro is to make for the Cape of Good Hope, the opportunity will present, should she steer sufficiently southerly, for many interesting observations with respect to the *connecting current* W.N.W. and E.S.E. which encounters that from Madagascar and Mozambique, close to the Cape, more especially with regard to the temperature of the sea.

If the frigate is intended to approach the small cluster of islands of Fernando de Noronha, E. of Pernambuco (Lat. 3° 50′ S.), I would recommend to that excellent geognostic, Dr. Hochstetter, the hornblendic phonolithe rock found there, far from a volcanic crater, but with trachytic dykes and basaltic amygdaloid. The flat little island of St. Paul (Peñedo de San Pedro), 1° N. Lat., singular to say, is not volcanic at

all, containing, like the Malouin or Falkland Islands, slaty green-stone passing into serpentine.

Should the frigate alter her course and cross the Equator more to the eastward, without touching at Rio de Janeiro, she might possibly fall in with the Marine Volcanic region, (Lat. 0° 20′ S., Long. 22° W.), which has quite lately become famous again by the U. S. Expedition of the Brig *Dolphin* (1854), commanded by Lieutenant Lee. On 19th May, 1806, columns of black smoke were seen issuing from the sea by Krusenstern, and volcanic ashes were gathered, after a singular bubbling of the sea from 1748 to 1836, according to careful investigations by Daussy.

As the frigate is commissioned to visit Ceylon and the Nicobar Islands, she cannot sail direct from the Cape to Australia; and the hope must therefore be abandoned of her visiting the small basaltic islands, known as Prince Edward's (47° 2′ S., 38° E.), and Possession (46° 28′ S., 47° 30′ E.), belonging to the Crozet's Group, or the two islands, long confounded with each other, of Amsterdam (Lat. 37° 48′ S.) and St. Paul (Lat. 38° 38′ S.) The latter island, the more southerly of the two, (a very characteristic drawing of which was given by Willem de Vlaming so far back as 1696), is supposed to be volcanic, not only by its form, which will at once remind the geologist of Santorin, Barren Island, and Deception Island, (one of the New Shetland group), but also in consequence of the eruption of steam, and the flames occasionally observed there.

As for Amsterdam, which consists of a single densely-wooded mountain, the puzzle remains for solution as to how, during the expedition of D'Entrecasteaux in 1792, the whole island seemed, during two entire days, enveloped in smoke; whereas, on landing there, the naturalists of that expedition were satisfied that the mountain was not an

active volcano, and that the columns of steam issued out of the ground near the shore! As yet, the phenomenon remains entirely unexplained.

If we examine any map of the Indian Ocean, we may trace the continuation of the Sunda group from Sumatra, N.W., through the Nicobar, and Great and Little Andaman Islands, and thence through the volcanoes of Barren Island, Narcondam and Cheduba, nearly parallel with the coasts of Malacca and Tenasserim, all on the eastern part of the Bay of Bengal. The minor volcanoes just enumerated will present valuable opportunities of geological enquiry.

Along the coasts of Orissa and Coromandel, the western portion of the Bay of Bengal is quite free of islands, Ceylon, like Madagascar presenting rather the type of a continent.

Off the W. coast of the peninsula of India, (that is opposite the Neilgherrie hills, and the coast of Canara and Malabar), there is a series of three archipelagoes, extending from 14° N. to 8° S., viz., the Laccadives, the Maldives, and the Chagos, which appears, as it were, continued through the banks of Sahia di Malha, and Cargados Carajos, to the volcanic group of the Mascarenhas and Madagascar. As the first-named archipelagoes, so far as is yet known, consist solely of coral, and are, consequently, true "atolls," or reef-lagoons, the bottom of the ocean should be examined over a large extent, adopting the ingenious hypothesis of Darwin, that it is to be considered *as an area of subsidence*, rather than an elevated region.

It would also be a matter of great importance to get observations respecting terrestrial magnetism, particularly so as to define the position of a given segment of the magnetic equator. Capt. Elliott, as the result of his comprehensive studies, (1846–49), ascertained that the magnetic equator passes through the north end of Borneo,

and thence nearly due W. to the northern extremity of Ceylon. In this region the curve of minimum intensity is nearly parallel to the magnetic equator, which intersects the Continent of Africa near Cape Guardafui—according to Rochet d'Héricourt, in lat. 10° 7′ N., long. 38° 5′. E. Between this point and the Bight of Biafra nothing is known.

The South Asiatic islands comprise Formosa, the Philippines, the Sunda group, and the Moluccas. The great and little Sunda Islands and the Moluccas embrace 109 volcanoes, with fiery eruptions, and 10 what are called mud-volcanoes. This is not a mere estimate, but is the result of an enumeration by Junghuhn, who, within the last year (1856), has returned to Java, and thoroughly equipped by M. Pahud, Governor-General of the Indian Netherlands, will be of great assistance to the Imperial Expedition.

An exact mineralogical determination of the volcanic rocks (trachytes) is unfortunately wanting everywhere.

The most active volcano of Sumatra is the Gunung Merapi (8980 feet), which must not be confounded with a volcano in Java, of the same name. That of Sumatra was ascended by Dr. L. Horner, and Dr. Korthals in 1834. We may pronounce Indrapura (11,500 feet, but this measurement is very uncertain), and Gunung Pasoman (9010 feet), the Ophir of our maps, to be utterly unknown geologically. The highest of the Java volcanoes is Gunung Semeru (11,480 feet), ascended by Junghuhn in 1844, 1220 feet higher than the Etna. The largest craters of the 45 which are disposed in a line along the shores of Java, are Gunung Tengger, and Gunung Raou. Dr. Junghuhn has recently given the outlines of each separate volcano in his splendid topographical and geological map of Java, in four sheets, published in 1856, which does great credit to the Dutch Government.

The following subjects are worthy of special attention while the frigate is at Java.

1. The curious phenomenon of the ribbed surface. (*Vide* Junghuhn, Java, Part II., p. 608.)

2. The disposition, as yet unaccounted for, of a series of regularly-shaped hills, formed by the mud-streams ejected in the year 1822 by the volcano of Gunung Galungung. (*Vide ut suprà*, pp. 127–731.)

3. The ejection of water by the Gunung Idjen, on 21st January, 1817, (pp. 707, and 717–121).

4. The erroneousness of the assertion that the volcanoes of the Island of Java do not emit streams of real lava.

It must be admitted that the mighty Javanese volcano, Gunung Merapi, already alluded to, has not, within the historic period, presented any coherent compact streams of lava, but mere fragments and boulders; although in 1837, lines of fire were seen running uninterruptedly from the top down the sides of the cones in eruption. But each of the three volcanoes, Tengger, Idjen, and Slamat, present examples of black lava currents, descending as far as the tertiary strata.

Streams of stone-boulders, red-hot, similar to those of the Cotopaxi, but scarcely touching each other, flowed from Gunung Lamorgan on 6th July, 1838.

No active volcano is known in the island of Borneo. The highest mountain of the whole island, perhaps of the whole insular world of Southern Asia, is the Hina Baïlu (12,850 feet?) on the northern point of Borneo. It is as yet unexplored. According to Dr. Lewis Horner, son of the astronomer of the Krusenstern expedition, there occur among the syenite and serpentine mountain range of Rathus, on the S.E. of the island, deposits yielding gold (which has even been worked by diggings), diamonds,

platinum, iridium, and osmium—presenting, in fact, a similar association to those of the Ural mountains. No mention is made of palladium. Rajah (now Sir James) Brooke describes in the province of Sarawak in Borneo, a low hill, Gunung Api ("hill of fire" in Malay), the slags of which attest former volcanic activity. A visit to Borneo would be of very great service.

There are eleven volcanoes in Celebes, and six in Flores, all active.

It is still uncertain whether the conical mountain Wawari, or Atiti, which is more generally known as the volcano of the island of Amboyna, ever poured out anything except hot mud (1674), or whether it should be merely classed as a *solfatara*. The main group of the South Asiatic Islands is connected through the Moluccas and the Philippines with the Papua and Pellew islands, and the Caroline Archipelago of the South Sea.

The most important geological fact to be remarked with reference to the island of Formosa, abounding in mineral coals, is the break in the line of direction of the open vents, when, instead of N.E. to S.W., the central line follows the meridian line, which it pursues nearly as far as 6° S., passing through Formosa and the Philippine Islands (Luzon and Mindanao), respecting which deviation nothing certain is known, and in which region every mountain of conical shape, or outline is invariably set down as a volcano, even though there should be no indications of a crater. The Sooloo Archipelago forms the connecting link between the islands of Borneo and Mindanao, the long, narrow island of Palawan, constituting that between Borneo and Mindoro.

The Island of Yesso, separated from that of Niphon by the Straits of Sangar, or Tsugar, and from the islands of Krafto (Saghalien) and Tschoka, or Tarakai, by the Straits of La

Pérouse, connects, through its North Eastern Cape, with the archipelago of the Kuriles. From Broughton's Southern Vulcan Bay up to its northernmost point, Yesso is traversed by an uninterrupted range of volcanoes—a fact the more worthy of being recorded, as in the expedition of La Pérouse there were found red porous lavas, as well as wide areas, covered with slags, in the Baie des Castries, in the narrow island of Krafto (Saghalien), which is, as it were, merely a continuation of Yesso. In our own day these regions command a higher interest, from a political point of view, more especially since Russia, dissatisfied with the situation of Okhotsk, at the sanded mouth of the Amoor, was anxious, after the destruction of Petropaulowski, on the coast of Kamtschatka, to obtain, on the S.E. coast, a harbour suitable for a military station.

Among the three islands which form the main portion of the Japanese Empire, six volcanoes are known to have had eruptions in the historic period. The volcano, Fusi Jama, in Niphon, province of Suruga (Lat. 35° 18′ N., Long. 136° 15′ E., altitude 11,675 feet), is said to have risen out of the plain 286 years before the Christian era. Its last eruption was in 1707. The volcano, Asama Jama, in the district of Saku, between the meridians of the two capitals, Miaco and Jeddo, was last in eruption in 1783. On the island of Kiusiu, adjoining the peninsula of Corea, four volcanoes are situated, from one of which, called Wanzen, there was a most destructive eruption in 1793.

The beautiful work of Commodore Perry, U.S.N., detailing his mission to Japan, on the part of the United States Government, in 1852, containing excellent photographs of races, as also drawings by the Berlin artist, Wilhelm Heine, does not, as yet, comprise the scientific results of that expedition.

Proceeding northwards, the volcanoes are more densely crowded, and are found arranged in series. Of the fifty-four which I enumerated as still in activity among the islands of Eastern Asia, there are thirty-four on the Aleutian, and ten on the Kurile Islands. The Peninsula of Kamtschatka contains nine volcanoes, which have been in activity within the historic period. Lying under the 54th and 60th degrees of northern latitude, we see a long strip of sea-bottom between two continents undergoing a perpetual process of destruction and re-arrangement.

The South Sea, the superficial extent of which is one-sixth greater than that of the entire solid crust of our planet, actually presents a smaller number of active volcanoes, less vents for communication between the centre of the earth and its atmospheric envelope, than the single Island of Java! Out of 40 volcanic cones, including those which are extinct, only 26 have been seen in eruption during the historic period. They are not scattered at random, but, on the contrary, as was pointed out by Mr. James Dana, the ingenious geologist of the great United States Exploring Expedition, under the command of Capt. Wilkes (1838–42), they have been thrown up, at widely extending clefts, communicating by submarine mountain systems. They are arranged in groups and distinct regions, analogous to the mountain chains of Central Asia and Armenia (in the district of the Caucasus), and belong to two quite distinct systems, one running S.E. to N.W., the other S.S.W. to N.N.E.

In the Hawaiian Archipelago (or Sandwich Island group), we find Mauna Loa, according to Wilkes, 12,900 feet in height, which does not present any cone of volcanic scoriæ (resembling, in this particular, the volcanoes of the Eifel), but has emitted streams of lava. The lava basin of Killauea, 13,000 feet in its greatest, by 4800 in its smallest diameter,

is not a *solfatara*, but a true lateral vent on the flank of the powerful Mauna Loa itself, exactly resembling the less elevated sheet of lava of Arak. Mauna Kea is 180 feet higher than Mauna Loa, but is extinct. Tafoa and Amangura, in the Tonga group, are still in eruption, the last discharge of lava having occurred in July, 1847. The volcano of Tanna was in full eruption during Capt. Cook's Voyage of Discovery in 1774, as was also the volcano of Ambrym, west of Malicollo in the archipelago of the New Hebrides. At the south point of New Caledonia, lies Matthew's Rock, a small smoking rocky island. The volcano of Santa Cruz, N.N.W. of Tina Kora, with periodical eruptions occasionally occurring at intervals of 10 minutes, had been already noticed as a volcano by Mendana, so far back as 1595. In the Salomon Archipelago, there is found the volcano of Sesarga, while others are said to be in full activity in the Marianas or Ladrones, just like those of Guguan, Pagon, and El Volcan Grande de Asuncion, which appear to have broken forth along a line that follows the meridian. In New Britannia, three conical mountains were observed vomiting streams of lava, by Tasman, Carteret, and Labillardière. There are two volcanoes in full activity on the north-east coast of New Guinea, opposite Admiralty Islands, which themselves are so rich in obsidian. In New Zealand, numerous regions abound in basaltic and trachytic rocks. Of active volcanoes there are Puhia-i-Wakati (the volcano of White Island), and the lofty cone of Tongariro (5816 feet). To the absence of centres of volcanic agency in New Caledonia, where sedimentary formations and seams of coal have recently been discovered, is ascribed the vast development of coral reefs. Dana was the first to ascend the Peak of Tafua, in the Island of Upolu, one of the Samoa group, not to be confounded with the still active volcano of Tafoa, south of Amangura, in the Tonga Archipelago. Dana

found in it a crater overgrown with thick forest. So, too, on the isolated Vaihu or Easter Island group, there is found a range of conical mountains with craters, but inactive.

Of the volcanic groups of the South Sea, the most violent is the farthest east, adjoining the shores of the New World, viz., the archipelago of the Gallipagos, which consists of five considerable islands, very admirably described by Darwin. There are streams of lava down to the very shore of the sea, but no pumice. Some of the trachytic lavas are said to abound with crystals of albite. It is important to examine whether or not this is oligoclase, as on Teneriffe, Popocatepetl, and Chimborazo; or labradorite, as on Etna and Stromboli. Palagonite, exactly similar to that of Iceland or in Italy, was discovered by Bunsen in the specimens of tufa from Chatham Island, one of the Gallipagos.

New Holland does not show any signs of recent volcanic activity, except at its most southern point (Australia Felix), at the foot of the Grampian Mountains. N.W. from Port Philip, as also towards the Murray River, there are numbers of volcanic cones and sheets or flows of lava.

It would be of great interest and utility to observe the relative inclinations of the Magnetic and the Geographical Equators, by means of the dip of the magnetic needle, though this will be rendered more difficult, from the fact of the ship's course being easterly, that is, contrary, to the Equinoctial current. As regards the low temperature of the current, which I discovered in 1802, running up from 40° S. to the Gallipagos along the coast of South America, and then turning westward, it would be highly important to investigate whether in the eastern part of the South Sea in 7° N. and between 117° and 140° W., there really exists in every season a *counter current* from west to east. But I

need not enlarge upon this topic to such attentive navigators.

The line of no inclination was crossed six times by Duperrey between 1822 and 1825. When I first discovered, near Truxillo, the low temperature of the cold Peruvian current, it was 12°·8 Réaumur (60°·8 Fahr.). The temperature observed in the course of twenty years by Mr. Dirckinck von Holmfeld, in the neighbourhood of Callao, expressed in degrees of Réaumur, were as follows:—

September 1802	12°·8	(Fahr.	60°·8)	Thermometer in the air. 13°·3 Réaumur. (61°·92 Fahr.)
November 1802	12°·4	"	59°·9	
December, end of	16°·8	"	69°·8	
January 1825	12°·7	"	60°·57	
February 1825	15°·3	"	66°·42	
March 1825	15°·7	"	67°·32	
April 1825	14°·5	"	64°·62	

The temperature of the sea I found to be 22° Réaumur (81°·5 Fah.) north of Cape Blanco, when on my way from Callao de Lima, at which point the cold current diverged towards the Gallipagos.

Between the Gulfs of Guayaquil and Panama, north-east of the cold current, the temperature of the sea during the month of April rose as high as 24°·5, (87°·12 Fahr.). Within

the range of the current, Mr. Dirckinck had carried on his observations in compliance with my instructions, by means of thermometers that had been compared by Arago. Everywhere in the current, in December 1824, he found from 16° to 18° (68° to 72°·5 Fahr.); between Quilca and Callao, in January, 1825, from 18° to 19° (72°·5 to 74°·75 Fahr.); between Chorillos, near Lima (Lat. 12° 39′ S.) and Valparaiso, in August, 1825, from 13°·8 to 10°·5 (63°·05 to 55°·62 Fahr.); between Chorillos and San Carlos de Chiloe, in June, 1825, from 18°·8 to 9°·2 (74°·3 to 52°·7).

In sailing from the Sandwich Islands to the west coast of America, the Imperial Expedition will have to choose between the Ports of San Francisco or Acapulco. The first choice would be of great mineralogical advantage for those regions of the United States, lying North of the river Gila.[3] Parallel with the chain of the Rocky Mountains, which, according to Marcou, contains up to the present day several volcanoes in full activity in its northern part (Lat. 46° 12′ N.), run single, and at certain points double ranges of coast chains from San Diego to Monterey, from 32° 15′ N. to 46° 45′ N. They begin with the coast range specially so-called, which is a continuation of the high ridge of the Peninsula of Lower or Old California; after which, farther to the North, there follow in succession, first the Sierra Nevada di Alta California, between 36° and 38° N. the lofty Shasty mountains, and the Cascade Range, nearly twenty six miles distant from the littoral, including many high and active volcanoes, and extending far beyond Fuca Straits. The following are still in eruption:—Mount St. Elias (46° 2′ N.); Mount Regnier, or Rainier, (46° 46′); and Mount Baker, (48° 48′.) These three active cones would be most conveniently visited by the geologist of the expedition from San Francisco, as would likewise the whole Cascade Range. We

have as yet no certain intelligence as to the geology of the entire longitudinal auriferous valley of the Sacramento River, (where a trachytic crater, in a state of disintegration, is known as the Butt of Sacramento). Does the auriferous quartz occur in veins, and are these still *in situ*, or are they broken up? What description of rock is traversed by these veins? Does the wash-gold here contain occasionally, as in the Ural Mountains, fragments of vein-stones with isolated cavities, in which are found impressions of leaves and membranes, clearly proving that they have not been rolled, or transported by water, any great distance to the spot they now occupy? Have these been found, alongside of gold, diamonds, platinum, osmium, iridium, or mercury?

Should the frigate steer for Acapulco, it may be assumed that there exists an intention to cross the Continent to Mexico and Vera Cruz, from the volcano of Colima (1877 toises) as it were, along the parallel of the range of volcanoes, and greatest heights rising in detached groups between the two seas, about the parallel of 19° N. New astronomical observations are greatly needed for determining the position of the volcanoes of Colima and Jorullo (667 toises). The volcano of Colima, with its twin peaks *de fuego* and *de nieve*, should be carefully examined, as also the volcano of Jorullo, with the fragments of granite enclosed in its lava; the Nevado de Toluca (2372 toises), Popocatepetl (2772 toises), Itztaccihuatl (2456 toises), Cofre de Perote (2098 toises), and the volcano of Tuxtla (18° 28′ N.), on the eastern slope of the Sierra St. Martin, from which a column of flame shot up with great violence on 2nd March, 1793, a fair specimen of what the Spaniards term *Malpays*, the Sicilians *Sciarra viva*. The face of the country is covered over with boulders of lava, at San Nicolas de los Ranchos, at the foot of Popocatepetl, adjoining the city of Puebla de los

Angeles, after which, on the road from Puebla to Vera Cruz, will be observed two narrow strips of boulders of cooled basaltic lava, rich in olivine. Similar examples will be found at Parage de Carros, near Tochtilacuaja and Loma de Tablas, between Cancas and the Casas de la Hoja. The mere ascension of volcanic cones is geologically of far less importance, than the bringing away numerous specimens, carefully selected, of various trachytic rocks, which, by their oryctognostical composition, are characteristic of each volcano. I would nevertheless recommend that the Pico del Fraile of the Toluca volcano (2372 toises) should be ascended, proper caution being used. From this very sharp peak, I brought away thin plates of trachyte perforated by lightning, and within the holes of a melted glassy surface, resembling those brought from Little Ararat. Both for the miner and geologist, an interesting and useful visit might be paid to the rich mines of Guanaxuato and the Mines de la Biscaina and Regla, on the road from Mexico to Real del Monte, so as to observe the close connection subsisting between the richer silver ores, occurring in trachytic porphyry without quartz, but with felspar, (glassy felspar?), and the thoroughly volcanic Cerro del Jakal, abounding in obsidian, and the Cerro de las Navajas (Razor Range), which remind one of the environs of Schemnitz, with the sole exception, that the trachytes "*porphyres meulières*" of Beudant, are wanting here.

As it is highly desirable that considerable time should be devoted to the volcanoes of Quito, Peru, and Chili, it appears uncertain whether the course of the frigate, on leaving Acalpulco, will be shaped direct for Guayaquil, thus reversing the route taken by myself, or whether she will not touch at some of the central American ports—Realejo or Sonsonate. The crowded series of volcanoes in Central

America, of which no less than eighteen, conical or dome-shaped, may be considered as still in active eruption, would yield a rich harvest of facts of all kinds in elucidation of the theory of volcanic action, such as have never hitherto been sufficiently taken advantage of. We are still in need of the mineralogical determination of the rocks, while the form and situation of the mountain masses have been well described by Squier, Oersted, and other modern travellers. The greater number, indeed, of the eruptions of scoriæ and slag were unaccompanied by streams of lava, as, for example, those of Mount Isalco, abounding in ammonia. But recently eye-witnesses have furnished us with quite different accounts regarding these eruptions, in the case of several volcanoes—as the Nindiri (a twin volcano with that called Massaya), on which Dr. Scherzer has lately shed much light; the Volcano el Nuevo, erroneously called Volcano de las Pilas, that of Coseguina, situated on the Great Bay of Fonseca, and that of San Miguel de Bosotlan, from which there flowed an extensive stream of lava in July 1844. It would be most tempting to pass by land from Mexico southwards to Oaxaca, and thence to the Isthmus of Guasacualco or Tehuantepec, and Chiapas, so as to rejoin the frigate at Realejo or Sonsonate. Facts might be obtained, in such a journey, of great value in determining the dependence of geological phenomena on each other; but it is to be feared it would be attended with too much fatigue and loss of time. For similar reasons, it cannot be proposed that the scientific gentlemen attached to the Expedition, should leave the frigate for three or four months, when they reach Central America, in order to cross by rail the Isthmus of Panama, with the object of examining the Volcancitos of Turbaco and Gabra Zamba, both active, and thence ascend the Rio Magdalena from Carthagena de las Indias, as far as

Honda, whence they could proceed by Bogotà and Popayan to Quitó.

It will be also unavoidable to forego the examination of the sedimentary rocks, rich in fossils, between Honda, Bogotà and Ibagues, the Mastodon fields (*Campos del Gigante*), and the Salto de Tegumidama on the plateau of Bogotà, the wax palm (*Ceroxylon Andicola*), and the Azufrales of the Passo de Quindiu, the volcanoes of Tolima, measured by myself and ascended by Boussingault, and of Paramo de Ruiz (4° 15′ N.), as also the two volcanoes of Popayan, the Puracé and the much more interesting but now extinct Sotará. As a middle course, I may suggest a disembarkation, not exactly at Guayaquil, but on the gold and platinum coast of the Choco, near San Buenaventura, so as to proceed thence to Popayan, and afterwards return to the volcanoes of the province of Pasto, which are highly important, and so on to Quitó, by way of Guachucal, Tulcan, and Villa de Ibarra, rejoining the frigate only at Guayaquil.

I believe, however, it would be more advisable to select Quitó as the starting-point, whence to examine the important elevated volcanic region De los Pastos (between 2° 20′ and 0° 56′ N.), containing the volcano of the town of Pasto, the volcanoes of Tuguerres, Chiles and Cumbal, and the Azufral de Pasto, and not to land at any port of the Choco coast, not even from the Bahia de Cupica, which for half a century I have recommended in vain on account of its vicinity to the Rio Naipi, one of the tributaries of the Atrato. In drawing up a list of names of the volcanoes of the renowned lofty plateau of Quitó, I may include, Imbaburu, Cotocachi, Rucu, Pichincha, Antisana, the much-disputed question of the stony walls like streams of lava, on the east slope of Tana Volcan, and Reventazon de Ansango; Cotopaxi, with its strange inexplicable quarries of pumice, of

Guapecho and Zumbalica, in the neighbourhood of Llactacunga and San Felipe, the pumice containing oligoclase, not glassy felspar, deposited in strata, like any rock *in situ* for a considerable distance on all sides of Cotopaxi; Tunguragua (mica slate), studded with garnets, and beds of granite, which dip under the former, and have themselves been pierced by the trachytes of Tungurahua at Rio Puela and the Hacienda de Ganace; the hills of Moya, near the village of Pelilco, cast up in the celebrated earthquake of 7th February, 1797, and still in a state of activity; the Chimborazo, which M. Jules Rémy, accompanied by an Englishman named Princkley, was in the belief they had ascended, on the 3rd of November, 1856, to the very summit, "*mais sans s'en douter*." Poggendorff, (Vol. X. p. 480), has clearly demonstrated that the boiling point given by Rémy for the summit, would not give 6544 mètres (little different from my own trigonometrical admeasurement of 6530 mètres), but fully 7328 mètres. As I distrust my own half-barometical measurements, I have vainly implored travellers, these fifty years past, to have a new series of trigonometrical observations made of the summit of Chimborazo. The merit, then, of settling this moot point, it also remains for the members of the *Novara* Expedition to obtain.

It would be important to examine the Sangay (16,068 feet)—which, like Stromboli, is in constant activity, yet without any traces of lava-streams—on account of the grains of quartz discovered by Wisse in the trachytic boulders ejected by the volcano, which is of such rare occurrence in the trachytes out of Hungary; and also on account of the close vicinity of beds of granite and gneiss, which are broken through by the Sangay trachyte, forming an island, as it were, of not hardly two miles in breadth. Still

more deserving of attention is the extinct volcano El Altar de los Collanes (Capac Urcù) a sketch of which I presented in the atlas published in my "Kleine Schriften" (Plate V. p. 461), formerly higher than Chimborazo, and still (?) 16,380 feet. Not a single specimen of its trachyte has ever been deposited in a European museum. The Altar itself is readily accessible from Riobamba Nuevo. In its vicinity may also be seen mica slate and gneiss, cropping out at the Paramo del Hatillo near Guamote, and Teocaxas, which are so seldom fallen in with in the highlands of Quitó. Tradition relates that gold-mines were worked here during the days of the Incas, in the neighbourhood of volcanic trachytes. From the Altar the geologist might proceed, by way of San Luis, (Query, whether the primitive clay-slate found here be of the Silurian formation?) and Guamote, to Paramo del Assuay (2428 toises), and Cuenca, as far as Atausca (2° 13′ S.), where an immense mass of sulphur, lying in a quartz seam is worked, forming a bed in the mica slate. Of what rock does the easily accessible Cayambe Urcù (18,170 feet) consist, crossing the Equator, S.E. of Otavalo? *En route* from Quitó to Cayambe, the rich deposits of obsidian near Quinche should also be inspected, which furnished the large mirrors to the Incas, and farther to the north of which are the volcanoes of Los Pastos, which form a separate system by themselves.

For examining the rocks and exploring the volcanoes of Southern Peru and Bolivia—respecting which see the last edition of Pentland's Maps, not those published between 1830 and 1848, in which the height of Sorata was indicated at 3949 toises (25,257 feet), and Illimani at 3753 toises (24,004), and accordingly both as much more lofty than Chimborazo, which is 3350 toises (21,426 feet)—the best starting-point would be the port of Arica, which may be

reached, sailing the whole distance against the cold current, from Guayaquil, after a short stay at Callao de Lima. Of the volcanoes of Peru and Bolivia only three are now active.

(*a.*) The volcano of Arequipa, three miles N.E. of the town of the same name, which, according to Pentland and Rivero, is situated about 7366 feet above the level of the sea. The measurements of M. Dolley, of the French navy, which were published under my superintendence, give the summit of the volcano as 10,348 feet above the town of Arequipa, so that its total elevation above the sea would be 17,714 feet. In the table of heights for Mrs. Somerville's "Physical Geography," Mr. Pentland speaks of the summit as being 20,320 English feet in height, or 19,065 Paris feet, closely approximating to the old trigonometrical measurement (19,080 feet) given by Thaddeus Haenke, a Bohemian, who accompanied the expedition of Malaspina, in 1769. What a deplorable state for the science of hypsometry to be in! which the *Novara* ought to put an end to. Samuel Anzon, a North American, in 1811, and Dr. Weddell, in 1847, have ascended the volcano of Arequipa.

(*b.*) Sahama (18° 7' S.), according to Pentland's new map of 1848, is 871 feet higher than Chimborazo (which he gives as 20,970 feet), and is still active. The true heights of Illimani and Sorata, ascertained since 1848, are, instead of 3949 and 3753 respectively, only 3329 toises (21,266 English feet), and 3307 toises (21,145 English feet).

(*c.*) Volcano Gualatieri, in the Bolivian province of Carangas (18° 25′ S.), height 20,604 feet.

The southern group of South American volcanoes, that, of Chili, presents the largest number of active fire-mountains—only second, indeed, to that of Central America, there being from eleven to thirteen. In order to increase the geological exploration of this region which has been so well prepared

by the memorable expedition under Captain Fitzroy, in the ships *Adventure* and *Beagle*, the excellent generalizing theories of Mr. Darwin, and the naval astronomical expedition of Mr. Gilliss, for 1849–51, the *Novara* will probably land at Valparaiso. A great desideratum between Coquimbo and Valparaiso is an exact measurement of—

A. The volcano of Aconcagua (32° 39′ S.). Its height has been stated, in 1835, by Captain Fitzroy, as 21,767 feet, Pentland's correction assigning 22,431 feet; while Captain Kellet, of the frigate *Herald*, gives it as 21,584 feet. Miers and Darwin are both of opinion that the Aconcagua is still in activity, which is denied by Pentland and Gilliss. The most recent measurement of Aconcagua—that by Pissis in 1854 (see Gilliss, Vol. I. p. 63)—makes the height 20,924 feet. M. Pissis has published, in the "Anales de la Universidad de Chili," for 1852, the geodetical elements of his survey, which is based upon eight triangles. Aconcagua being probably the highest mountain in the New World, a new measurement is eminently desirable. Neither Dhawalagiri, with his 4930 toises, nor Kintsinjunga, measured by Colonel Waugh, with his 4406 toises, are any longer considered the highest mountains in the Himalaya range, but the Deodunga (Mount Everest), which is 29,003 English feet, equal to 27,212 Paris feet, or 4535 toises.

B. The volcano Maipu (34° 17′ S., height 16,572 feet), ascended by Meyen. The trachytic rock on the summit has broken through the Jurassic strata, in which Leopold von Buch has ascertained, from heights of 9000 feet, the existence of *Exogyra couloni*, *Trigonia costata*, and *Ammonites biplex*. This volcano has no streams of lava, but only eruptions of volcanic slags. It would be most desirable that Dr. Hochstetter should examine this remarkable protrusion of dislocated strata.

C. The volcano Antuco (37° 7′ S.), the geology of which was described by Pöppig, is a lofty basaltic crater, having a trachytic cone rising up in its centre to an elevation of 8672 feet. It was observed in full activity by Domeyko in 1845. Gilliss gives an account of an eruption in 1853. According to Domeyko, a fresh-burning cone was thrown up on the 25th of November, 1847, which remained in activity for a whole year. Molina considers the Nevada Descabezado (35° 1′ S.), ascended by Domeyko, to be the highest mountain in Chili; but its height is estimated by Gilliss at only 12,300 feet. The most southerly volcanoes are the still active Corcovado (43° 12′ S.), 7046 feet; Yanteles (43° 29′ S.), 7534 feet; and the Volcan de San Clemente, opposite the granite formation on the peninsula of Tres Montes. Still further south, in 51° 41′ S., another, the Volcan de los Gigantes, is laid down on the old maps of South America, by La Cruz Olmedella, as opposite the archipelago of La Madre de Dios.

Should the *Novara* return to Europe through the Straits of Maghellanes, it would be very desirable the members of the Expedition should visit the locality from which Prince Paul of Würtemberg, after long zoological travels through North America, has, within the last year, brought back to Germany a very large collection of specimens.

Altogether, I calculate the number of active volcanoes on the surface of the earth to be upwards of 225—one-third of which, or 75, are upon the various continents, and the remainder upon the insular world. The Western Continent has 53 active volcanoes—of which, North-Western America, north of the river Gila, has 5; Mexico, 4; Central America, 18; South America about 26. Viewing the globe as a whole, there presents itself an extensive oblique region in which volcanoes most abound, stretching from S.E. to N.W. in the more westerly part of the Pacific, between 75° W. and 125°