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ARTICLE

Sixteenth-Century Bulge on the Coast of Chile

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ABSTRACT

This paper traces the sixteenth-century addition and removal on maps of a bulge on the southern coast of Chile. Abraham Ortelius was primarily responsible for these changes and many cartographers followed his lead. Then, Ortelius rotated the coastline of Chile from northwest to north. Later, he dropped the latitude of the islands of San Pablo and Isla de los Tiburones down six degrees. He named the Amazon River "Río de las amazons." Finally, he removed the cities with fake Native-American-sounding names along the Pacific coast of North America. The research underlying this paper examined over seven-hundred sixteenth-century maps made by six-dozen cartographers. This paper cites five-dozen maps by four-dozen cartographers. In the traceability section of this paper, this information was condensed into a traceability diagram, which shows the chronological flow of information among a score of cartographers. Using this information, this paper traced the influence of one cartographer on another: it showed who influenced whom. It showed the spread of knowledge. Ortelius was at the center of most of this knowledge explosion.

1. Introduction

In the mid-sixteenth century, printed world maps began showing the west coasts of the South and North American continents. Most maps were similar: each subsequent map maker just added details. Examining Sebastian Cabot's 1544 map (Figure 1) shows an incipient bulge on the southern coast of Chile. This bulge might have grown into the bulge of Girolamo Ruscelli and subsequently into the bulges of Abraham Ortelius and Gerard Mercator 1569-70 (Figure 2). In the next thirty years, dozens of cartographers followed their lead.

The next world-shaking change occurred in 1588 when Ortelius *removed* the bulge on the southern coast of Chile: again almost everyone followed suit. In 1587 Ortelius rotated the coastline of Chile from northwest to north: other cartographers followed. Once again, Ortelius seems to have been the leader in removing the westward lean of the Chilean coast. Later in 1589, he dropped the latitude of the islands of San Pablo and Isla de los Tiburones down six degrees. For example, on his maps, he moved San Pablo from 15° S latitude to 21° S latitude. Again a whole

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group of cartographers followed him. In 1570 he invented the name "Río de las amazons" (River of the Amazons) and dozens of cartographers did likewise. Finally, in 1589, he removed the cities with fake Native-American-sounding names along the Pacific coast of North America: others eventually followed him.

These actions (adding ① and removing the bulge on the southern coast of Chile, rotating the coast of Chile, 'moving' San Pablo and Isla de los Tiburones, naming the Amazon River, and removing the cities with Native-American sounding names) indicate that Ortelius was the leader and a dozen or more cartographers followed his lead.

Aim: The aim of this paper is to show the sixteenth-century evolution of the bulge on maps of the southern coast of Chile.

Scope: The scope of this paper is printed sixteenth-century nautical world maps.

The Literature Review for this paper consists of listing the cartographer, the name of the map being cited, and its year of publication. This literature review is in the appendix. These 65 maps listed in the appendix are then linked to their URLs with http://sysengr.engr.arizona.edu/URLsForSixteenthCenturyMaps.xlsx.

2. Materials and Methods

This paper traces changes from cartographer to the cartographer. Our most successful technique for exploring the traceability of sixteenth-century nautical maps was analyzing visually distinct features on these maps. For example, we investigated the bulge on the southern coast of Chile. Features like that are the focus of this paper. This is not a traditional history paper as is common in the field of geographic exploration and discovery. It does not present the religious, familial, or national relationships of the cartographers. Rather it introduces systems engineering tools into nautical cartography. In this study, these tools are traceability and tradeoff studies. We did not make a statement about a map and then reference an earlier paper that made a similar statement. Rather we made a statement and then pointed to a feature on a map that supported the statement. Furthermore, the "literature review" section of this paper is given in the appendix as a list of maps that have relevant information. Using these maps, this paper traces particular geographical features and suggests who instigated the changes.

① We are not saying that Ortelius invented the bulge on the coast of Chile. He did not: Ruscelli did. We are merely saying that many cartographers followed Ortelius. We will discuss this later.

Fourteenth- and fifteenth-century Portolan charts ② and sixteenth-century world maps had features, and toponyms that came and went. These features and toponyms were moved geographically and their shapes were changed. They were continually added but seldom removed. Changes were rarely explained. An exception that proves this rule is the Francesco Beccario [1] (Franciscus Becharius) Portolan chart of 1403. On this chart, he wrote to his readers that he had moved Sardinia and changed the distance scale of the Atlantic with respect to the Mediterranean. This type of explanation was very unusual in Portolan charts.

In contrast, starting with Ortelius in 1570, atlases had much more off-the-map text than they had maps. For example, Ortelius's 1571 atlas *Theatrum Orbis Terrarum* comprises 200 pages of which only 95 are maps. This present paper investigates prominent features like the bulge on the southern coast of Chile precursors of which might have shown up in 1544 and the bulge itself faded away starting in 1587. We suggest that Girolamo Ruscelli was the cause of its appearance and Abraham Ortelius was the cause of its disappearance.

The research underlying this paper examined over seven-hundred sixteenth-century maps made by six-dozen cartographers. This paper cites five-dozen maps by four-dozen cartographers. In the traceability section of this paper, this information was condensed into a traceability diagram. This diagram shows the chronological flow of information among a score of cartographers. Using this information, this paper traced the influence of one cartographer on another: it showed who influenced whom.

3. Results

3.1 Magellan's Voyage, AD 1519 to 1522

Ferdinand Magellan did not leave a map of his circumnavigation of the world in 1519-22 [3]. However, we do have the logbook of his pilot Francisco Albo [4]. It records that on 2 December 1520, they were off the coast of Chile at 47° S latitude. From there they sailed up the coastline for fourteen days with an average azimuth of 20°, NNE. On 16 December at 36° S, they changed course to go northwest, out into the Pacific Ocean. This means that for two weeks they followed the Chilean coast, and

② Portolan charts are mostly fourteenth and fifteenth-century nautical charts of the Mediterranean and Black Seas. Their coastlines are crowded with names of cities, towns, ports, harbors, rivers, points, capes, etc. They are detailed and accurate. They were built on a framework of interconnected rhumb lines emanating from maybe eight or sixteen compass roses encircling the canter of the map. They were the first large-area maps since the lost maps of Ptolemy of the second century AD.

covered 740 miles (we use statute miles in this paper) with an average speed of 50 miles per day (which is reasonable for ships of the day in that region) and an average azimuth of NNE. {In Albo's notation the 16 quarter winds were named using the symbol ¼, for example, "N ¼ NE." This would be an azimuth of 11.25°. The modern notation would call this North by East or NbE.} The point is that Magellan sailed *easterly* up the coast of Chile, not westwardly. ③

3.2 Add South America to World Maps, AD 1540s

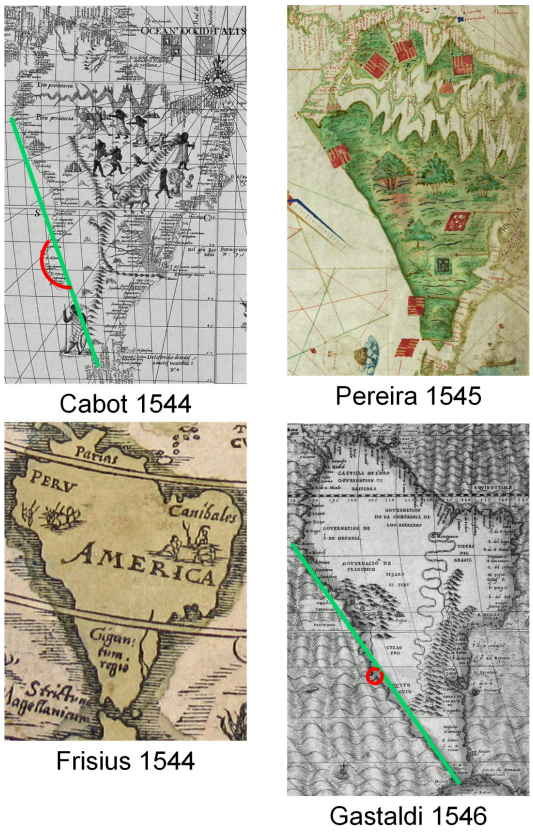

Figure 1. Sections of contemporary sixteenth-century maps of South America. Land to the west of our green line is defined as the bulge. For most maps in this paper, the meridians of longitude and the parallels of latitude are ten degrees apart. However, on Cabot's map, they are only five degrees apart. All of the maps in this paper are over 400 years old: hence they are not subject to copyright restrictions. Modifications to the original figures belong to the author.

The illustrations in Figure 1 come from these maps.

• Sebastian Cabot, 1544, *World Map of A. D. 1544*

• Gemma Frisius, 1544, *La Cosmographie de Peter Apian ...*

• Antonio Pereira, 1545, *Early representation of Newfoundland, Lower California, the Amazon, and the Ladrones*

• Giacomo Gastaldi, 1546, *Universalet*

We have a database that lists and gives URLs for all maps mentioned in this paper. It is at this location http://sysengr.engr.arizona.edu/URLsForSixteenthCenturyMaps.xlsx.

In Figure 1, Cabot and Antonio Pereira have drawn the Amazon River as a giant snake, as was common between 1544 and 1600. However, Gemma Frisius does not have an Amazon River and Giacomo Gastaldi has his Amazon River running from south to north! Cabot and Gastaldi have a suggestion of a bulge on the coast of Chile, indicated with red arcs.

In 1541-1542, a Spanish conquistador and explorer, Francisco de Orellana, and his crew sailed the length of the Amazon River from *west to east.* ④ They were the first Europeans to explore this river [5]. The next year, in Portugal, they plausibly shared their travel logs with the Portuguese Captain Antonio Pereira. Then he or some unknown Portuguese cartographer created a world map containing South America. On it, the Amazon River is shaped like a giant snake with its tail in the Andes Mountains and its head on the coast of the Atlantic Ocean (Figures 1 and 2) [6]. At about the same time that Orellana was sailing down the Amazon River, Sebastian Cabot explored the Americas for Spain. From his first-hand knowledge and knowledge from other cartographers, he created his map of the world. ⑤ A third cartographer, Gemma Frisius, created a globe in 1536 (with the assistance of his graduate student Gerard Mercator) and a world map in 1544. It also had South America. A fourth

③ We assume that Albo's azimuth measurements were made with a magnetic compass. According to https://maps.ngdc.noaa.gov/viewers/historical_declination/ in 1590 the magnetic declination along the coast of Chile between 47° S latitude and 36° S latitude was between +4° and +6° east of north. This means that when Albo thought they were heading 11° east of north, they were actually heading 16° east of true north. This is even farther eastward than we had expected.

④ Orellana and his crew had no intention of sailing to the Atlantic ocean, when they started their trip on the Pacific coast. They merely intended to climb the Andes. But when they found themselves at the bottom on the east side, they decided it would be easier to sail down the Amazon River rather than climb back up the Andes. They had brought nails with them, so they chopped down trees and made boats. Then they sailed east to the Atlantic Ocean. In this paper, we tried to base our judgments strictly on what was on the maps. But in this case, we must comment that this trip was so harrowing, the sailors probably exaggerated all details.

⑤ The year 1544 is widely accepted as the date this map was created/published. However, no copies of the original map exist. The copy in the Boston Public Library contains a date of 1544, which was probably added in 1897: https://collections.leventhalmap.org/search/commonwealth:7h149v62n. There are several older copies in the BnF: Bibliothèque nationale de France, https://data.bnf.fr/12574640/sebastien_cabot/ and https://gallica.bnf.fr/ark:/12148/btv1b55011003p/f1.item This is the only map attributed to Sebastian Cabot.

cartographer, Giacomo Gastaldi, created his map in 1546. The shape of South America is similar on all four of these world maps in Figure 1. Note that the west coast of Chile slopes at about a 20° angle, NNW, in these maps. This is contrary to the direction given in Albo's log of Magellan's voyage, which was NbE, and contrary to its actual azimuth. Figure 6 shows that from 45 °S latitude up to the Tropic of Capricorn the actual coast slopes 8° eastward. Even so, for the next four decades, the maps of the South America held this incorrect NNW slope, see for example Guillaume Le Testu 1556, Diogo Homen 1558, Paolo Forlani 1560, Bartolomeu Velho 1561, Diego Gutiérrez & Hieronymus Cock 1562, Ortelius 1564, Donato Bertolli 1568, Domingos Teixeira 1573, Giovanni Massa 1580, and Bartolomeu Lasso 1586.

In the Atlantic Ocean, at the Equator, near the mouth of the Amazon River, the maps of Ortelius (and many subsequent maps) have labeled it Rio de las Amazons. Some of the details in this paper, like this label, might be too small to see on the published figures. Therefore, we have provided a list of Internet sources for the maps mentioned here. This list/database is located at http://sysengr.engr.arizona.edu/URLsForSixteenthCenturyMaps.xlsx. This list contains URLs for high-resolution original maps that are mostly in the public domain: that is, they are free of known restrictions under copyright law. Just click on a URL in this file and you will be connected to an original map.

The earliest maps we have found containing the whole continent of South America are those made by Pereira 1545, Frisius 1544, Cabot 1544, and Gastaldi 1546 shown in Figure 1. We do not assert a chronological order amongst these four maps because the dates are only estimates and the cartographers would have been working on these maps concurrently for a long time.

3.3 Add a Bulge to the Coast of Chile, AD 1561-70

Pereira and Frisius have no hint of a bulge on the southern coast of Chile. However, the maps of Cabot and Gastaldi have a suggestion of an incipient bulge on the coast. Two decades later, prominent bulges appeared on maps.

We have a database that lists and gives URLs for all maps mentioned in this paper. It is at this location http://sysengr.engr.arizona.edu/URLsForSixteenthCenturyMaps.xlsx.

Table 1 lists a few cartographers/maps produced between 1544 and 1587 that might have a bulge on the southern coast of Chile. To categorize these maps we used the coordinates of two distinct geographical points: the Pacific Ocean exit from Straits of Magellan, which has coordinates (52.6° S, 74.7° W), and the westernmost point in South America, the Punta Pariñas, which has coordinates of (4.7° S, 81.3° W). We drew a line between these two points. Everything to the west of this line is called the bulge. We measured the east-west distance between the center of the protrusion and this line and called it the Protrusion Distance.

The 1544 Cabot map shows a small bulge on the southern coast of Chile. Afterward, Gastaldi 1546 and 1548, Tramezzino 1554, and Forlani 1560 followed with small bulges of their own. However, if you were not looking for a bulge on these maps, then you probably would not see one. They are small.

Then, Ruscelli 1561, *Orbis Descriptio,* Forlani 1562*, La.Descrittione. di. Tutto.ll. Peru.* and *Gastaldi and Some Others 1562-65* produced big bulges on their coasts of Chile. These bulges instigated the bulges of the next two decades that are shaded with red in Table 1.

In 1561 Girolamo Ruscelli in his *Orbis Descriptio* map in his *La Geografia di Claidio Tolomeo Alessandrino …* atlas (which was just one more translation of Ptolemy's *Geographia*) put a bulge on the southern coast of Chile, below the Tropic of Capricorn as shown in Figure 3. Except for this bulge, this map looks like a copy of Gastaldi's 1546 map *Universale*. In seventeen years the bulge was the only addition.

The next maps with prominent bulges are the Forlani 1562 and the Gastaldi and Some Others 1562-65 maps. The text at the bottom of the *Cosmographia Universalis et Exactissima …* the map indicates the creators as "… Gastaldio Nounullisque Aliis …," which translates as "Gastaldi and Some Others ..." Therefore we will refer to this map as Gastaldi and Some Others 1562-1565.

Figure 3. Ruscelli's 1561 *Orbis Descripto* map, contained in his atlas *Geography by Claudio Tolomeo Alessandrino, translated from Greek into the Italian vernacular by Girolamo Ruscelli.* Land to the west of our green line and below the Tropic of Capricorn is defined as the bulge on the southern coast of Chile. (Only the western hemisphere of his map is shown here.)

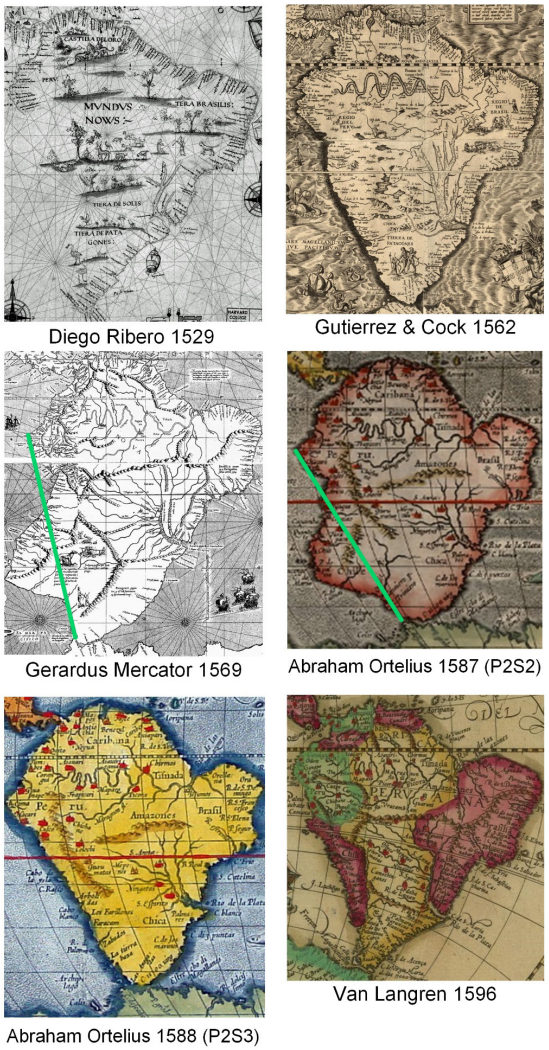

Figure 2. South American sections of sixteenth-century maps. ⑥ Land to the west of our green line is defined as the bulge. This bulge appears on the southern coast of Chile just below the Tropic of Capricorn on the maps of Mercator 1569 and Ortelius 1587. It is not on the maps by Gutiérrez & Cock 1562 [7], Ortelius 1588, or Van Langren 1596. The abbreviations P2S2 and P2S3 will be explained later in section 3.4. Unless noted otherwise, parallels of latitude and meridians of longitude are spaced ten degrees apart on maps in this paper.

The illustrations in Figure 2 come from these maps.

- Ribero 1529, *Carta universal en que se contiene todo lo que del mundo se ha …,*
- Gutiérrez & Cock 1562, *Americae Sive Quartae Orbis Partis Nova …,*
- Mercator 1569, *Nova et Aucta Orbis Terrae descriptio …,*
- Ortelius 1587 (P2S2), *Typus Orbis Terrarum,*
- Ortelius 1588 (P2S3), *Typus Orbis Terrarum,* and
- Van Langren 1596, *Orbis terrae compendiosa descriptio …*

⑥ Here are some words commonly used on charts and maps of this era followed by some abbreviations:
Island; Ilsa, Isla, Iland, Islet, Iles, Isole, ysola, Eylant, I., Y.
Port; Puerto, P., Pt.
Cape; cabo, c.
River: rio, R.,
Saint; santo, S., san.,
In alphabets of this era, the 's' was often elongated (e. g. iſland) making it the tallest letter. This was a characteristic of the Italic type face designed by Ludovico Arrighi 1527. The 'i' is the vowel form of 'i' and the 'j' is the consonant form of 'i'. The 'u' is the vowel form of 'u' and the 'v' is the consonant form of 'u'. The word *diver* means various.

Table 1. Progression of the size and location of the bulge on the southern coast of Chile

Cartographer	Year	Latitude of the bulge, °S	For the point of the bulge, Degrees west of the Straits of Magellan exit	For the point of the bulge, Degrees east of Punta Pariñas	Protrusion Distance, degrees of longitude	Shape of the bulge	Estimated Area of the bulge in degrees of longitude squared
Actual coast	2021	48 to 50	1	5.6	1	Flat	
Cabot	1544	34	13	5	5	Dome	
Gastaldi	1546	32	8	9	5	Skin tag	
Gastaldi	1548	31	3	1	3	Dome	
Tramezzino	1554	30	8	-2	2	Cone	
Forlani	1560	32	6	10	4	Skin tag	
Ruscelli	1561	22 to 49	30	4	13	Dome	157
Forlani	1562	5 to 41	28	-5	19	Cone	310
Gastaldi and Some Others +	1562-65	5 to 41	28	-5.1	19	Cone	420
D. Homen	1565	24 to 43	33	1	20	Dome	50
Mercator	1569	27 to 47	16	-6	13	Cone	130
Ortelius	1570	34 to 43	20	-6	18	Dome	265
Francois de Belleforest	1575	34 to 43	20	-6	18	Dome	88
Ortelius	1587 P2S2	34 to 43	20	-6	18	Dome	225
+The lines of latitude and longitude are 15 degrees apart on this map by Gastaldi and Some Others							

This bulge is centered, on average, at 35° S latitude in Table 1, except for Forlani 1562 and the Gastaldi and Some Others 1562-1565. It was often shaped as in Figure 3. We are still developing a quantitative characterization of the shapes of these bulges.

Ruscelli put this bulge on his *Orbis Descripto* map in all versions of his atlas *La Geografia di Claudio Tolomeo* … 1561, 1562, 1564, 1574, 1598 and 1599. (He did not put the bulge on his 1562 *Terra Nova* or his 1561 Carta Marina Nuova Tavola.)

The following cartographers/maps of this era do not have this bulge: Frisius 1544, Pereira 1545, Pierre Descelier 1550, Lopo Homen 1554, Velho 1561, Gutiérrez & Cock 1562, and Ortelius 1564. The next cartographers who included this bulge on the southern coast of Chile were Gerard Mercator and Abraham Ortelius in 1569-70.

In 1570, Ortelius published the first modern atlas, *Theatrum Orbis Terrarum*. Then he updated and reissued it just about every year. The *Typus Orbis Terrarum* (TOT) maps in his atlases from 1570 to 1587 had the bulge on the coast of Chile [8]. Mercator and Ortelius were early adopters of this big bulge in 1569-70. Others followed suit in adding a bulge to the southern coast of Chile, for example, André Thevet 1575, Nicola Van Sype 1581, Joan Martines 1587, Rumold Mercator 1587, Urbano Monte 1587, Sebastian Munster 1588, Cornelius De Jode 1589 (published in 1593), and Michael Mercator 1595. Some cartographers didn't get the word and continued to publish maps without the bulge after 1569-1570, for example, D. Teixeira 1573, Massa 1580, and Lasso 1586.

3.4 Remove the Bulge from the Coast of Chile, AD 1587-88

In 1587-1588, Ortelius made a dramatic change: he *removed* the bulge on the southern coast of Chile. To be precise, he removed the bulge on the 2nd plate in the 3rd state (P2S3) of the *Typus Orbis Terrarum* (TOT) map printed in 1588 (Figures 2 and 4). He did the same on his *TOT* 1587 P3S1 (published in 1592), his *Americae sive novi orbis nova descripito* ... 1587, and his *Maris Pacifici* 1589 ⑦. In contrast, the Mercator family kept putting this bulge on their maps into the seventeenth century. These maps by Ortelius do not have the bulge on the coast of Chile: *Typus Orbis Terrarum* 1588 and on, *Americae sive* ... 1587 and on, and all *Maris Pacifici*. These maps were all contained in his atlases: they were not published individually. So these dates have more credibility.

In Figure 4, the only differences between the two maps are to the left of the green line. The bulge is the pink region to the left of the green line. A misalignment of the text can be seen in the bottom part of this figure, to the right of the Straights of Magellan. Otherwise, all of the letters are superimposed.

In Figure 2, the abbreviations P2S2 and P2S3 on the

⑦ The year given for each map is only an approximation. I usually list the 1588 P2S3 *Typis Orbis Terrarum* before the 1587 *American Sive* …, because that is the way they are usually listed in historical documents. There is no absolute of how to list maps chronologically. Should we use the date the map was conceived? When it was finished? When it was published? When the atlas containing it was published? etc. I usually used the year given by the map owner. So take all dates with a grain of salt.

Ortelius 1587 and 1588 maps stand for plate-2 state-2 and plate-2 state-3, respectively [9]. Most maps of this era were engraved on copper plates and printed from these plates. The printers would print a batch of maps and then set the plates aside. When they needed more maps, they would retrieve the plates and print some more. When the plates wore out, they would engrave a new set of plates. Maps printed with this second set of plates are called plate-2 by modern historians [9]. Each set of plates would have occasional changes. Maps printed with these changed plates are called state-1, state-2, state-3, etc.

Figure 4. Superimposing Ortelius's *Typus Orbis Terrarum* (TOT) 1588 P2S3 map of Figure 2 onto his 1587 P2S2 map of Figure 2 shows the size and shape of this bulge on the southern coast of Chile. The bulge comprises almost one million square miles, which is four times the size of Spain.

For the Ortelius *Typus Orbis Terrarum* (TOT) map the first set of copper plates lasted through 16 printings from 1570 to 1575. In 1575 the lower-left corner cracked and was repaired [9]. Maps printed with this cracked set of plates are called TOT plate-1 state-2 (P1S2). Ortelius made minor alterations to his plates and in 1579 published his atlas containing TOT plate-1 state-3 (P1S3). In 1584 he published TOT plate-1 state-4 (P1S4) and in 1585 he published TOT plate-1 state-5 (P1S5).

Then, after printing hundreds of maps, the first set of plates wore out. So Ortelius and his engraver Franciscus Hogenberg engraved a new set of plates in 1586. They are called TOT plate-2 state-1, or in our shorthand P2S1. They erased the date from the plates in 1587 and printed the maps now called TOT plate-2 state-2 (P2S2) as in Figure 2. In 1588 they removed the bulge on the southern coast of Chile and printed TOT plate-2 state-3 (P2S3) also shown in Figure 2 [9]. In 1587 they engraved their third set of plates for TOT. They engraved the date 1587 on them. (Evidentially they did not use these plates for five years.) These plates were used from 1592 to 1612. They are called TOT plate-3 state-1 (P3S1). Finally, plate-3 state-2 (P3S2) maps began to be printed in 1628.

The following maps do not have the bulge on the southern coast of Chile: Ortelius TOT 1588, etc., *American Sive ... 1587,* etc., and *Maris Pacifici* 1589,

After 1588 some cartographers continued to publish maps with the bulge on the southern coast of Chile, for example, Munster 1588, C. De Jode 1589 (first published in 1593), Theodor de Bry 1592, M. Mercator 1595 and into the seventeenth century, and Ruscelli 1599 (this is a different map, but it still has a bulge). Others either followed Ortelius' lead and removed the bulge on the southern coast of Chile, or they had never put it there in the first place, for example, Jodocus Hondius 1595 and 1597, Richard Hakluyt 1589, Emery Molyneux 1592 [10]. Petrus Plancius 1594, Jan Baptists Vrient 1596, João Lavanha & Luis Teixeira 1597, Edward Wright & Emery Molyneux 1598, and Matteo Ricci 1602.

We have found no explanation for *why* Ortelius removed the bulge on the coast of Chile. However, this mistake in the maps seems to have vexed Sir Francis Drake, who wrote [11],

"… we continued our course, *Nouember* 1, [1578] still North-west, as wee had formerly done, but in going on we soone espied, that we miglit easily haue beene deceiued; and therefore casting about and steering vpon another point, wee found, that the generall mappes did erre from the truth in setting downe the coast of *Peru*, [Drake refers to the whole coast as Peru, not differentiating between Chile and Peru. Drake continues describing the section of the coast between 52° S and 40° S latitude.] … perceiuing hereby that no man had euer by trauell discouered any part of these 12. deg., and therefore the setters forth of such descriptions are not to be trusted, much less honored, in their false and fraudulent coniectures which they vse, not in this alone, but in diuers other points of no small importance."

At the end of his circumnavigation of the world, Drake returned to England in 1580. Molyneux was a crewman on Drake's circumnavigation. We conjecture that they expressed Drake's displeasure to some cartographers because most cartographers later changed their maps. This conjecture is supported by Drake's written words

above, and the *Silver Map* of ca. 1588-89. These maps were stamped onto silver disks about 68 mm in diameter. A photograph of the western hemisphere of one of these is shown in Figure 5. Notice that the bulge on the coast of Chile has been removed. This map also shows Drake's route of circumnavigation with dotted lines.

Figure 5. The *Silver Map*, probably created in 1588-89. Only the western hemisphere is shown here.

The British Museum's two copies of the *Silver Map* are silver medals 68 mm in diameter (2.7 inches, about the size of a baseball) stamped with a map of the world showing Drake's route of circumnavigation with dotted lines. They were probably manufactured in 1588-89 [12]. Neither of these medals has a bulge on the southern coast of Chile. The face of one of them is shown in Figure 5. The Library of Congress also has two medals and lists the locations of all nine existing medals. ⑧ One of their medals has a cartouche in the ocean near Africa. This cartouche states that the medal's creator was Michael Mercator in 1589. The 1581 map by Van Sype was most likely published before these silver medals because, although it has the same route as Drake's circumnavigation, it still has the bulge on the coast of Chile. ⑨

We suggest that Ortelius used information provided by Drake and/or Molyneux when he removed the bulge from the coast of Chile. Other people followed his lead.

⑧ Library of Congress, The Kraus Collection of Sir Francis Drake, http://hdl.loc.gov/loc.rbc/rbdk.d058a. the Silver Map traces to the Whitehall map, which disappeared in the seventeenth century. The Whitehall map, in turn, traces to Drake's journal that he gave to Queen Elizabeth upon his return. She promptly disappeared it.

⑨ The 1587 map in Hakluyt's publication of Petrus Martyr does not have the bulge on the coast of Chile. The libraries at Brown and Stanford Universities agree with the date on the map of 1587, which matches information on the map, such as the Amazon River being shaped like a giant snake. However, they then state that the creator of the original map was Peter Martyr who died in 1526, which was well before the existence of the bulge on the coast of Chile. This cartographer was clearly from a different era. For example, he did not have the islands of San Pablo, Isla de los Tiburones, S. Felix and S. Nabor, and his zero-longitude meridian was 20 degrees off from everyone else.

3.5 Rotate the Azimuth of the Chilean Coast, AD 1587

We now have another problem to solve. Even if the bulge is gone, the coast of Chile is still wrong because on these maps the coast slopes northwest (Figure 4), instead of northeast (Figure 6).

Figure 6. Present-day South America in a Mercator map projection. The spacing between parallels and meridians is 15 degrees.

One of the cartouches on the Wright & Molyneux 1598 map states [13], "By the discoverie of Sir Francis Drake made in the yeare 1577 … the southern coast of [South] America called Chili was found, not to trend to the northwestwards as it hath beene described but to the eastwards of the north …"

The following maps do not have the bulge on the southern coast of Chile; however, they still have an average azimuth for the Chilean coast that is incorrectly west of north: Velho 1561, Gutiérrez & Cock 1562, Forlani 1565, Bertolli 1568, D. Teixeira 1573, Massa 1580, Lasso 1586, Plancius 1594, Vrient 1596, Lavanha & Teixeira 1597, and Hondius 1597.

At the same time that Ortelius removed the bulge from the coast of Chile, he also rotated the azimuth of his coastline between 52° S and 40° S latitude. He did this on his *American Sive* 1587 map by removing a section of Chile making the coast slope north or even northeast.

The resulting coastline has an average azimuth that is north or even *east* of north: Ortelius *American Sive* 1587, etc., Hondius 1595 and 1597, Wright & Molyneux 1598, and Ricci 1602. We were careful when calculating the azimuth of the coastline of Chile. We used the meridians of longitude because different map projections can be misleading.

Figure 7. A present-day map of South America overlaid on the Ortelius 1570 *Typus Orbis Terrarum*. These maps were aligned using the north and northeast coasts of South America, the Equator, the Tropic of Capricorn, and the Straits of Magellan. The Pacific side exit for the Straits of Magellan is marked with a black arrow. These maps show that when Drake exited the Straits of Magellan, his maps told him to go Northwest and then West by North, however, he should have gone North and then North by East.

Maps began to show the modern shape of South America at the beginning of the seventeenth century. The southern coast of present-day Chile has an azimuth of 8° eastward from 45 °S latitude up to the Tropic of Capricorn. We now note that the south*east* coast of Argentina and Brazil has an azimuth of 37° eastward from 45 °S latitude up to the Tropic of Capricorn. This then defines the shape of southern South America.

Our model for the shape of the southern part of South America is that of a trapezoid as shown in Figure 8. The Pacific side has an azimuth of 8° and the Atlantic side has an azimuth of 37°. The northern side of this trapezoid is along the Tropic of Capricorn and is 50° of longitude wide (3173 miles). The southern side of this trapezoid is along the forty-fifth parallel and is 17° of longitude wide (1079 miles). Throughout the seventeenth century, most maps used this shape for South America.

The Wright & Molyneux 1598 map shown in the background of Figure 8 is close to our model with azimuths of 7° eastward and 42° eastward respectively. So its shape is good but it's South America is too wide.

The purpose of creating such a model is to allow quick easy comparison of a large number of charts. Just put the trapezoid on top of the map and you can quickly see how accurate the map is.

Figure 8. A portion of the Wright & Molyneux 1598 map *By the discouerie of Sr Francis Drake made in the yeare 1577* is in the background. Our model for South America is the red trapezoid.

3.6 Drop the Latitude of San Pablo and Isla de los Tiburones, AD 1589

Now we have another complication to resolve. Removing the bulge from the coast of Chile in 1587-1588 and redirecting the Azimuth of the coastline northward might have caused Ortelius to reconsider the route of Magellan in 1519-1522 and consequently the locations

of San Pablo and Isla de los Tiburónes. Their locations are important because no one had ever visited these uninhabited islands except for Magellan and his crew. And we do not know where these islands were. Therefore, information about their locations had to come from word of mouth, letters, texts, atlases, charts, and other maps, not from first-hand observations, measurements, or calculations. Ortelius dropped the latitude of these islands on his *Maris Pacifici* 1589 map (Figure 9) and his *Typus Orbis Terrarum* 1587 P3S1 (published 1592). Maps published before 1589 (for example Agnese 1541, Gastaldi 1546 and 1565, Forlani 1560 and 1565, Bertelli 1568, G. Mercator 1569, Ortelius TOT 1570 to 1587, R. Mercator 1587, Hondius 1589, and C. De Jode 1593) have San Pablo island at, on average, 15° S latitude and Tiburones at 9° S. Whereas maps published after 1589 (for example Ortelius 1589 *Maris Pacifici*, Plancius 1594, Hondius 1597 and Wright & Molyneux 1598) have San Pablo island at, on average, 21° S and Tiburones at 15° S. Ortelius instigated this shift but we do not know why he did it. Perhaps he did it because removing the bulge altered his *concept* of Magellan's route.

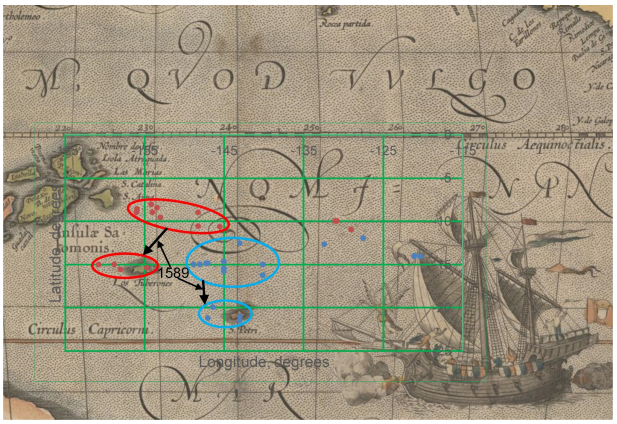

Figure 9. In this *Maris Pacifici* 1589 map, Ortelius lowered San Pablo island and Isle de la Tiburones by about six degrees in latitude. Others followed his lead as shown by the arrows between the ellipses. The numbers inside the green box in the Ariel font are present-day latitudes and longitudes. Magellan's ship the Victoria is being guided by the angel above its prow https://jcb.lunaimaging.com/luna/servlet/s/35yp7r

3.7 Traceability Analysis

Traceability is an important part of the Discovering System Requirements activity of the System Design process [14]. It has been used for decades in the field of system design and systems engineering. As far as we can tell, it has not been used in the field of geographic exploration and discovery. We have used processes from this activity to trace the ancestry of sixteenth-century cartographers/maps. This section traces cartographers/maps based on toponyms (names of cities, rivers, bays, capes, mountains, etc.) and the visual appearance of objects on ancient maps.

In this section, we review previous material and organize it into the traceability diagram of Figure 10. The dates are not strictly chronological, because in the sixteenth-century information did not travel at the speed of the Internet.

At the start of our traceability analysis of sixteenth-century cartographers/maps, we refer to four maps that were made around 1544-1546 by Pereira, Cabot, Frisius, and Gastaldi (Figure 1). There is one prominent visual difference between them. The Pereira and Cabot maps have the Amazon River represented as a giant snake with its tail in the Andes Mountains and its head on the coast of the Atlantic Ocean [6] as shown in Figure 1. The Frisius map does not have this representation. For this and many other reasons, the Frisius map is not included in our traceability chart in Figure 10. The *Carta universal en que se ...* by Diego Ribero 1529 (Figure 2) also lacks the Amazon River, however, it has many other features such as a label for the Straits of Magellan that inclined us to include it in Figure 10. ⑩

The ghost information flow path from the Pereira and Cabot box, which is the *Padrón Real* inside the *Casa de Contratación* in Spain, to Gastaldi's workshop in Genoa Italy is light gray. It would have been implemented with stolen documents.

We did not include all sixteenth-century cartographers in our traceability diagram. For example, cartographers in the Dieppe school in France made a series of world maps in the 1540s, 1550s, and 1560s, but they were not included in Figure 10. They had some similarities to these maps/cartographers, but no evidence of information flow.

We also omitted the Venetian cartographers Forlani, and Bertolli. They had similarities to these maps/cartographers, but not enough to include them in Figure 9. They formed an isolated branch. We have not proven a link between Forlani and Ortelius.

The same with Ruscelli. He was isolated in Venice. We cannot prove that Ortelius got his idea for the bulge on the southern coast of Chile from Ruscelli. We know

⑩ The history books state that Cabot never explored the Amazon River, so Cabot probably got his information from Pereira and his cartographers and possibly from Diego Ribero's 1529 *Map of America*. Therefore, Ribero is included in our traceability chart of Figure 10. His map may be the first to label the Straights of Magellan. Ribero worked on the *Patron Real* (1508-1606) at the Casa de la Contratacion in Seville as did Pereira, Cabot, Diego Gutiérrez (father), Diego Gutiérrez (oldest son) and Sancho Gutiérrez (middle son).

that Ruscelli published his map about nine years before Ortelius. But we cannot prove causality. Also, we cannot prove that there were a group of cartographers who copied from Ruscelli. Whereas we have made a case that many cartographers copied from Ortelius.

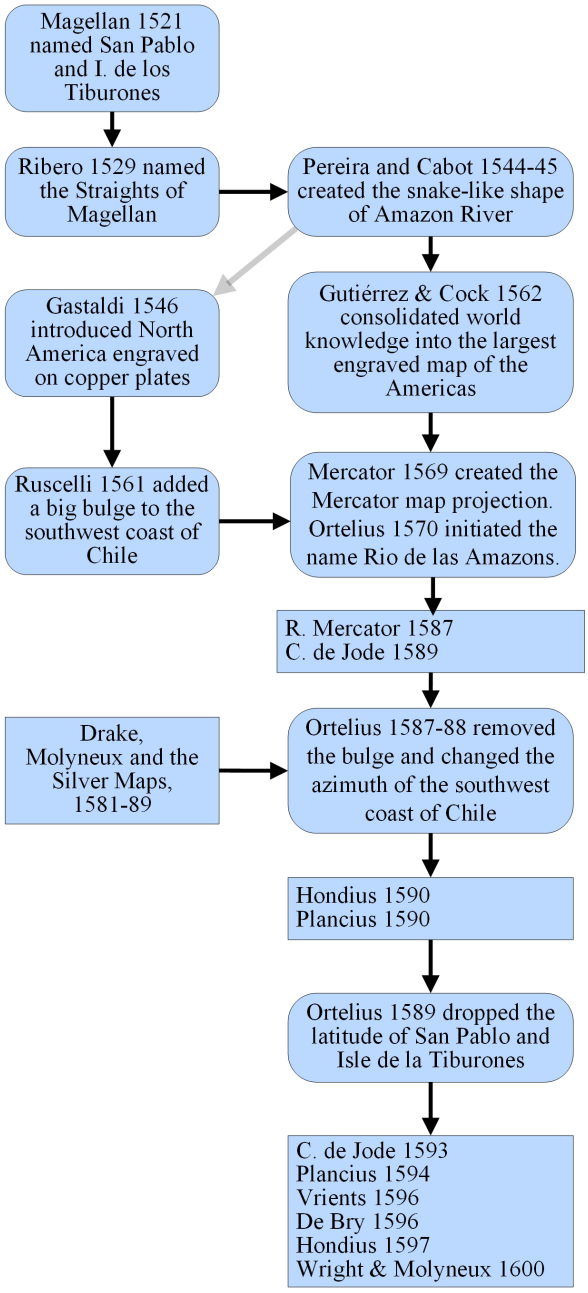

Figure 10. Traceability diagram for sixteenth-century cartographers/maps that contain South America. This diagram was derived from information on the maps themselves. Therefore, the dates are only approximations. Actions (verbs) are in boxes with rounded corners and objects (nouns) are in rectangles.

The following maps have visual appearances that are similar to each other but dissimilar to all other maps: R. Mercator 1587, Plancius 1590 and 1594, Hondius 1592, M. Mercator 1595, De Bry 1596, and Vrients 1596. Some have a bulge on the coast of Chile and some don't. They have a distinct appearance because they used the Mercator bi-hemispheric stereographic projection function introduced by R. Mercator in 1587. It uses curved parallels of latitude. We considered map projection functions but did not use them elsewhere in this paper.

3.8 Synopsis

The following page or so summarizes sections 3.3 to 3.7 of this paper. In the early sixteenth century, world maps began to present the Pacific Ocean coasts of South and North America. Most subsequent maps were similar: they just added details. We found no lead-cartographer or school of cartographers that initiated these changes.

Then in 1561, Ruscelli made a dramatic addition. He added a big bulge on the southern coast of Chile. In the next four decades, dozens of other cartographers produced maps with similar erroneous bulges on the coast of Chile.

At the end of his circumnavigation of the world in 1580, Sir Frances Drake most certainly pointed out the error of the bulge on the southern coast of Chile.

The next important change in maps occurred in 1588 when Ortelius removed the bulge on the southern coast of Chile (*Typus Orbis Terrarum* P2S3). He also made this change on his 1587 *Americae sive* map. Again everyone followed suit. After 1587-1588 some cartographers continued to publish maps with the bulge, for example, M. Mercator 1595. Others followed Ortelius' lead and removed the bulge on the southern coast of Chile, including the *Silver Maps* of 1588-1589.

At the same time, Ortelius realigned his coastline of Chile to make it north rather than northwest. The other cartographers followed. Ortelius modified his coastline so that from 52° S latitude to 40° S it had an azimuth of due north or perhaps slightly north*east*. Once again Ortelius seems to have been the leader in taking out the westward lean of the Chilean coast.

On his *Maris Pacifici* 1589 map and his *Typus Orbis Terrarum* 1587 P3S1 (published in 1592) Ortelius dropped the latitude of San Pablo and Isla de los Tiburones about six degrees each: again the whole group of cartographers followed him. Maps published before 1589 have San Pablo island at, on average, 15° S latitude and Isla de los Tiburones at 9° S. Whereas maps published after 1589 have San Pablo island at, on average, 21° S and Isla de los Tiburones at 15° S (Figure 9).

The first cartographer to name the Amazon River was Cabot 1544, who wrote: "Río de las amazona descubrio Francisco de orillana" (River of the amazon discovered

Figure 11. Rumold Mercator 1587 *Orbis Terrae Compendiosa Descriptio*

by Francisco de Orellana) [15]. The *river* is not named on the Pereira 1545 and L. Homen 1554 maps: instead, the *province* is named [15]. Cabot was followed by Sancho Gutiérrez 1551 who wrote "El Río … amazonae …," Velho 1561 who labeled it "Río de sa iohan de las amazonas" (River of Saint John of the Amazons) and Gutiérrez & Cock 1562 who labeled it "El grand rio de las amasons" (The grand river of the Amazons). Ortelius 1564 labeled it "Río de las Amasona sive Oregliana." Later, Ortelius 1570 shortened this to "Río de las amazons" (River of the Amazons). Some of these are shown in Figure 2.⑪ On this map, in the ocean next to the mouth of the river, the equator cuts between the words "Rio" and "de las" and between "Am" and "azones." This name and partitioning were then used on maps by R. Mercator 1587, Hondius 1590, Plancius 1590 and 1594, DeBry 1592 and 1596, and Vrients 1596. This same name with a different partitioning was used by C. de Jode 1589, Hondius 1597, and Wright & Molyneux 1598.

In 1540-1542 Francisco Vázquez de Coronado et al. journeyed through what is now New Mexico. They encountered many Native-American cities and villages, such as Tuchana, Quivira, Cicuic, and Tiguex. These names were probably attempts by Coronado to write in Spanish Native-American names that were only *spoken* by Native Americans. Later, the cartographers Ortelius 1564, Gastaldi 1565, Forlani 1565, and Bertelli 1568 spread these cities across the American west on their maps. In 1569-1570, Mercator and Ortelius moved these cities to the Pacific coast of North America. Dozens of cartographers followed their lead.

In 1589 Ortelius made a major change that was not immediately followed by other cartographers. Ortelius removed the cities with Native-American-sounding names: Tuchana, Quivira, Cicuic, and Tiguex from his *Maris Pacifici* 1589 map. He left Quivira as a region, however. Other cartographers did not follow his lead right away. A possible reason may be that he did not remove these cities from his *Typus Orbis Terrarum* maps. Tuchana, Cicuic, and Tiguex lasted on other maps into the second decade of the seventeenth century before disappearing.

In his Americae sive 1587 map, Ortelius added the islands of S. Felix and S. Nabor. Of course, each successive edition of this atlas also had this same map. Subsequently, C. de Jode 1593 *Brasilia et Peruvia* and Mercator & Hondius 1608 *Americae Descrip* also had these islands. Much later Claes Janszoon Visscher's 1650, map had them labeled S. Felix and S. Ambrosio. So, adding these islands did not immediately develop a lot of followers.

Ortelius developed the concept of an atlas. This is our eighth unique action by Ortelius. Before Ortelius, maps were designed, made, sold, and used separately. But in 1570, Ortelius published the first modern atlas of maps.

⑪ If the letters are too small in this journal paper then see http://sysengr.engr.arizona.edu/URLsForSixteenthCenturyMaps.xlsx. This list contains URLs for high-resolution original maps that are mostly in the public domain: that is, they are free of known restrictions under copyright law.

It was a collection of uniform map sheets and supporting text bound together to form a book. Copper plates were specifically engraved for the maps. This book was 37.5 by 50.5 cm (14.5 by 19.6 inches). It contained 70 maps on 53 sheets. It went through over twenty editions in four languages. It was followed by atlases by Gerard de Jode in 1578 and M. Mercator in 1595.

These eight actions (adding and removing the bulge on the southern coast of Chile, rotating the coast of Chile, 'moving' San Pablo and Isla de los Tiburones, naming the Rio de las Amazons, removing the cities with Native-American sounding names, adding the islands of S. Felix and S. Nabor, and creating an atlas) indicate that Ortelius was the leader and a dozen or more cartographers followed his lead.

This information is summarized in the traceability diagram of Figure 10 and Table 2. To be included in this diagram the specified map must have had most of the eight actions listed above. The blue shaded cells in Table 2 show abrupt changes in features. Time runs roughly from left to right.

4. Discussion

In keeping with our policy of using only information contained in the maps themselves, we now speculate that the cartographers Ortelius, G. Mercator, R. Mercator, M. Mercator, C. de Jode, Plancius, Hondius, De Bry, Vrients, and Molyneux formed a clique and shared common knowledge that was not necessarily in their published atlases or maps mentioned in this paper. We formulated this concept of a clique based on the maps. We did not rely on (1) historical texts, (2) sixteenth-century family, friendship and religious relationships, language, geographical location, or professional feuds, or (3) present-day human biases, speculation, and mistranslations.

In breaking with our policy of using only information contained in the maps themselves, we can observe that we have no maps with a bulge on the coast of Chile that was created by Spanish cartographers. This was unexpected because the Spanish were the only ones sailing the Pacific Ocean in the sixteenth century: it was a 'Spanish lake.' This could have been caused by the requirement that all Spanish maps are reconciled with the *Patron Real* (the master map) at the *Casa de la Contratacion* in Seville. This may have helped them avoid the mistake of the bulge on the coast of Chile. (I do not classify Martinis 1582 as Spanish.)

4.1 A Fly in the Ointment

Our results have shown that Ruscelli was the originator of the big bulge on the southern coast of Chile. His 1561 *Orbis Descripto* map (Figure 3) was the first map to show

Table 2. Major changes in the evolution of sixteenth-century world maps

Ortelius' Actions	G. Mercator, 1569	Ortelius, 1570 *TOT	R. Mercator, 1587	C. de Jode, 1589, *Totis Orbis Terrae*	Ortelius 1587, *Amer sive* ...	Ortelius, 1588, TOT P2S3	Ortelius, 1589, *Maris Pacifici*	Hondius, 1590	Plancius, 1590	Plancius, 1594	C. de Jode 1593, *Brasilia et Peruvia*	DeBry, 1596	Vrients, 1596	M. Mercator, 1595	Hondius, 1597	Wright & Molyneux, 1599
Include the bulge on the coast of Chile	√	√	√	√										√		
Remove the bulge on the coast of Chile					√	√	√	√	√	√	√	√	√		√	√
Rotate the coast of Chile northeast					√	√	No	√	No	No	No	No	No		√	√
Draw San Pablo at 15° S and Tiburones at 9° S	√	√	√	√	√	√		√	√					√		
Drop the latitude of San Pablo to 21° S and Tiburones to 15° S							√			√		√	√		√	√
Represent the Amazon River as a giant snake	√	√	√	√	√	√	No	√	√	√	No	√	√	√	√	√
Use the name *Rio de las Amazons*		√	√	√	No	√		√	√	√	No	√	√		√	√
Contain cities with Native-American-sounding names	√	√	√	√	√	√	No	√	√	√		√	√	√	√	√
Include the islands S. Felix and S. Nabor	No	No	No	No	√	No	No	No	No	No	√	No	No	No	No	No

*TOT stands for *Typus Orbis Terrarum*. Checkmarks (√) mean yes, No means No, and blanks mean no data is available or the cell is not applicable.

this bulge. The date is verified because this map was published in his atlas of 1561.

However, there is a slight problem here because the Forlani 1562 *La Descrittione* (Figure 12) and the Gastaldi and Some Others 1562-65 maps also have big bulges on their southern coasts of Chile. Furthermore, these maps were probably created at about the same time.

The Forlani map is straightforward and is shown in Figure 12. However, the Gastaldi and Some Others 1562-65 *Cosmographia Universalis et Exactissima* map would not reproduce well in a journal. So it requires some explanation.

The text at the bottom of the *Cosmographia Universalis et Exactissima ...* map indicates its creators as "… Gastaldio Nounullisque Aliis …," which translates as "Gastaldi and Some Others ..." Therefore we will refer to this map as Gastaldi and Some Others 1562-65. We do not know which sections of this map were created by which authors. So its authorship is fuzzy.

Figure 12. Forlani 1562, *La.Descrittione. di. Tutto.ll. Peru*.

The bulge on the Forlani 1562 map is identical to that on the Gastaldi and Some Others 1562-1565 map. Also, both maps have the same inconsistent shadows on the cartouches. So Forlani was probably responsible for the portion of the Gastaldi and Some Others 1562-1565 map that included South America. However, Forlani did not engrave this bulge on any of his other maps, e.g. Forlani 1560, 1562b, 1565, 1568, or 1570.

Looking further at the Gastaldi and Some Others 1562-1565 map we see about twenty animals spread across a large Antarctic continent. Some are real, like the wolf, elephant, lion, grasshopper, and armadillo, and some are mythical like the unicorn and the griffin. These animals are similar to the twenty on the map of Forlani 1565 (Figure 13) in looks and placement. The obvious conclusion, therefore, is that Frolani was responsible for the animals in Antarctica and the bulge on the coast of Chile on the Gastaldi and Some Others 1562-1565 map. Both of these maps have about a dozen ships and a dozen sea monsters. However, the ships and sea monsters are different on the two maps.

There is also some fuzziness here about the date of the Gastaldi and Some Others 1562-65 map because the map has little documentation. The Bibliothèque nationale de France (BnF) dates it from 1539 to 1565. Shirley [9] dates it as 1561 conjectured on a rare booklet published sometime around 1562.

So the authorship and date of this map are fuzzy. However, it still seems that this map was created after Ruscelli's.

The bulges on the coast of Chile on the Forlani 1562 *La Descrittion* and Gastaldi and Some Others 1562-65 maps are huge. They make South America diamond-shaped (Figure 12). See also Tommaso Porcacchi 1572, *Discorso Intorno alla Carta da Navigare*. These bulges extend from the Straights of Magellan all the way up to the Equator. Their sizes average 365 degrees squared. In contrast, the other big bulges listed in Table 1 are completely below the Tropic of Capricorn and have an average area of only 150 degrees squared ($\sigma = 80$). Therefore, the big bulge of Forlani does not seem to have been copied by later cartographers. He did not even include it in his own subsequent maps.

In summary, the Ruscelli 1561 *Orbis Descripto* map not only preceded the Forlani 1562 *La Descrittione* and the Gastaldi and Some Others 1562-65 maps but it was also the map followed by other cartographers for the next 27 years with regard to the bulge on the coast of Chile.

4.2 Area for Future Research

We were not successful in determining *why* the bulge was added to and removed from the southern coast of Chile. We searched the English language translation of Ortelius' *Theatrum Orbis Terrarum* looking for an explanation for the appearance and removal of the bulge but found none: perhaps the 1588 Latin version has an

Figure 13. Paolo Forlani 1565 P3S2 *Universale Descrittione Di Tutta la Terra Conosciuta Fin Oui.* Note that (1) Antartica is very large, (2) there are 20 animals in Antartica and (3) there is no bulge on the coast of Chile.

explanation. Likewise, there could be an explanation for the addition of the bulge in Ruscelli's Italian language atlas of 1599, *Geografia di Claudio Tolomeo Alessandrino, tradotta di greco nell'idioma volgare italiano da Girolamo Ruscelli.*

5. Conclusions

In the first half of the sixteenth century, world maps began to appear that contained the Pacific Ocean coasts of South and North America. Most subsequent maps were similar. The cartographers just added details over the years. Then in 1561, Ruscelli made a unique addition. He added a big bulge on the southern coast of Chile. In 1569-70 Mercator and Ortelius added bulges on *their* southern coasts of Chile. Dozens of cartographers followed their lead and produced maps with a bulge on the southern coast of Chile.

Using the information given to him after Drake circumnavigated the world, Ortelius removed the bulge from his *Typus Orbis Terrarum* 1588 and realigned the coast of Chile on his *Americae sive* 1587 and his *Maris Pacifici* 1589 maps. Again most cartographers followed suit.

At about this same time Ortelius also dropped the latitude of San Pablo and Isla de los Tiburones about six degrees: a whole group of cartographers followed him.

The first cartographer to name the Amazon River was Cabot 1544, named it the "River of the Amazon discovered by Francisco de Orellana." Ortelius 1570 shortened this to "River of the Amazons." Dozens of cartographers followed suit.

These eight actions (adding and removing the bulge on the southern coast of Chile, rotating the coast of Chile, 'moving' San Pablo and Isla de los Tiburones, naming the Amazon River, removing the cities with Native-American sounding names, adding the islands of S. Felix and S. Nabor, and creating an atlas) indicate that Ortelius was the leader and dozens of cartographers followed his lead.

In the sixteenth century, on printed world maps containing South America, a bulge four times the size of Spain appeared on the southern coast of Chile. Ruscelli first created this bulge. No one knows why, and no one back then questioned it. But dozens of cartographers followed his lead. Then 27 years later, without explanation, Ortelius removed the bulge from the coast of Chile. All cartographers followed his lead and soon the phantom bulge was gone forever.

Conflict of Interest

The author has no conflicts of interest.

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Ethical Approval

No ethical approval was necessary.

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Appendix

Literature Review

Table 3. Maps that are mentioned in this paper. They are listed in alphabetical order by the last name of the cartographer. URLs for these maps can be found at http://sysengr.engr.arizona.edu/URLsForSixteenthCenturyMaps.xlsx.

Cartographer	First Year Published	Title of Map
Agnese, Battista	1541	*Nautical Atlas of Battista Agnese*
Anonymous	1588-89	*Silver Map*
Becharius, Franciscus	1403	*Francischus becharius cuius lanue [con]posuit*
Bertelli, Donato	1568	*Universale Descrittione Di Tutta la Terra Conosciuta Fin Qui.*
Belleforest, François de	1575	*Typus Orbis Terrarum*
Cabot, Sebastian	1544	*World Map of A. D. 1544 (The Sebastian Cabot Map)*
De Bry, Theodor	1592	*Americae Pars Magis Cognita*
De Bry, Theodor	1596	*America Sive Novus Orbis Respectu Europaeorum Inferior Globi Terrestris Pars*
De Jode, Cornelius	1589	*Brasilia et Peruvia*
De Jode, Cornelius	Dated 1589, published 1593	*Totius Orbis Cogniti Universalis Descriptio*
De Jode, Gerard	1578	*Americae Peruvi aque ita ut post*

Descelier, Pierre	1550	*Chart of the Atlantic and Indian Oceans*
Forlani, Paolo	1560	*Paulus de furlanis Veronensis opus hoc exmi Cosmographi …*
Forlani, Paolo	1562	*La.Descrittione. di. Tutto.ll. Peru*
Forlani, Paolo	1565	*Universale Descrittione Di Tutta la Terra Conosciuta Fin Oui,*
Frisius, Gemma	1544	*La Cosmographie de Peter Apian …*
Gastaldi, Giacomo	1546	*Universalet*
Gastaldi, Giacomo	1548	*Universale Novo*
Gastaldi, Giacomo, and Some Others	1562-65	*Cosmographia Universalis et Exactissima …*
Gastaldi, Giacomo	1565	*Universale della parte*
Gutiérrez, Diego & Cock, Hieronymus	1562	*Americae Sive Quartae Orbis Partis Nova et Exactissima Descriptio*
Gutiérrez, Sancho	1551	*Esta Gerale en plano hizo Sancho Gutierrez Cosmographo*
Hakluyt, Richard	1589	*Typus Orbis Terrarum*
Homen, Diogo	1558	*A América meridional*
Homen, Diogo	1565	*Coastline of South America*
Homen, Lopo	1554	*Nautical mappamundi in four sections*
Hondius, Jodocus	1589	*America Novissima Descripto*
Hondius, Jodocus	1590	*Nova Universi Orbis Descripto*
Hondius, Jodocus	1595	*Vera totius expeditionis nauticæ: descriptio D. Franc. Draci.*
Hondius, Jodocus	1597	*Typus Totius orbis Terrarum in Quo (The Christian Knight map)*
Janszoon, Claes	1650	*None*
Le Testu, Guillaume	1556	*Cosmographie Universe*
Van Langren, Arnold	1596	*Orbis terrae compendiosa descriptio …*
Lasso, Bartolomeu	1586	*Portugaliae Monumenta Cartographica*
Lavanha, João & Teixeira, Luís	1597	*Atlas-cosmografia*
Martines, Joan	1587	*Portolan chart of South America …*
Martyr, Petrus	1587	*Novus Orbis (Map of the New World)*
Massa, Giovanni	1580	*America et Proximar Regionumorae Descriptio*
Mercator, Gerard	1569	*Nova et Aucta Orbis Terrae descriptio …,*
Mercator, Michael	1595	*America sive India Nova*
Mercator, Rumold	1587	*Orbis Terrae Compendiosa Descriptio*
Mercator, Gerard & Hondius, Jodocus	1608	*Americae Descrip*
Monte, Urbano	1587	*Planisphere of 1587*
Molyneux, Emery	1592	*The Petworth Globe*
Munster, Sebastian	1588	*Die erst GeneralTafel die Beschreibung …*
Ortelius, Abraham	1564	*Nova Totius Terrarum Orbis iuxta*
Ortelius, Abraham	1570	*Typus Orbis Terrarum*
Ortelius, Abraham	1587	*Americae sive novi orbis nova descriptio …*
Ortelius, Abraham	1587 P2S2	*Typus Orbis Terrarum*
Ortelius, Abraham	1588 P2S3	*Typus Orbis Terrarum*
Ortelius, Abraham	1589	*Maris Pacifici*
Pereira, Antonio	1545	*Early representation of Newfoundland, Lower California, the Amazon, and the Ladrones*
Plancius, Petrus	1590	*Orbis Terrarum Typus de Integro…*
Plancius, Petrus	1594	*Orbis Terrarum Typus de Integro…*
Ribero, Diego	1529	*Carta universal en que se contiene todo lo que del mundo …*
Ricci, Matteo	1602	*Kun Yu Wan Guo Quan Tu*
Ruscelli, Girolamo	1561	*Orbis Descriptio*
Ruscelli, Girolamo	1562	*Tierra Nova*
Ruscelli, Girolamo	1599	*Orbis Terrae Compenduiso Descriptio*
Ruscelli, Girolamo	1599	*Geografia di Claudio Tolomeo Alessandrino, tradotta di greco nell'idioma volgare italiano da Girolamo Ruscelli …*
Van Sype, Nicola	1581	*La Herdike Enterprinse Faict Par Le Signeur Draeck D'Avoir Cirquit Toute La Terre*
Teixeira, Domingos	1573	*World map*
Thevet, André	1575	*Le Nouveay Monde Descuvert*
Tramezzino, Michele	1554	*Wereldkaart in twee halfronden*
Velho, Bartolomeu	1561	*Mapa de Bartolomeu Velho*
Vrient, Jan Baptists	1596	*Orbis terrae compendiosa descriptio ex peritissimorum ….*
Wright, Edward & Molyneux, Emery	1598	*By the discouerie of Sr Francis Drake made in the yeare 1577*
Verified October 21, 2021		