"California No Es Ysla...."

By Ronald L. Ives

Introduction

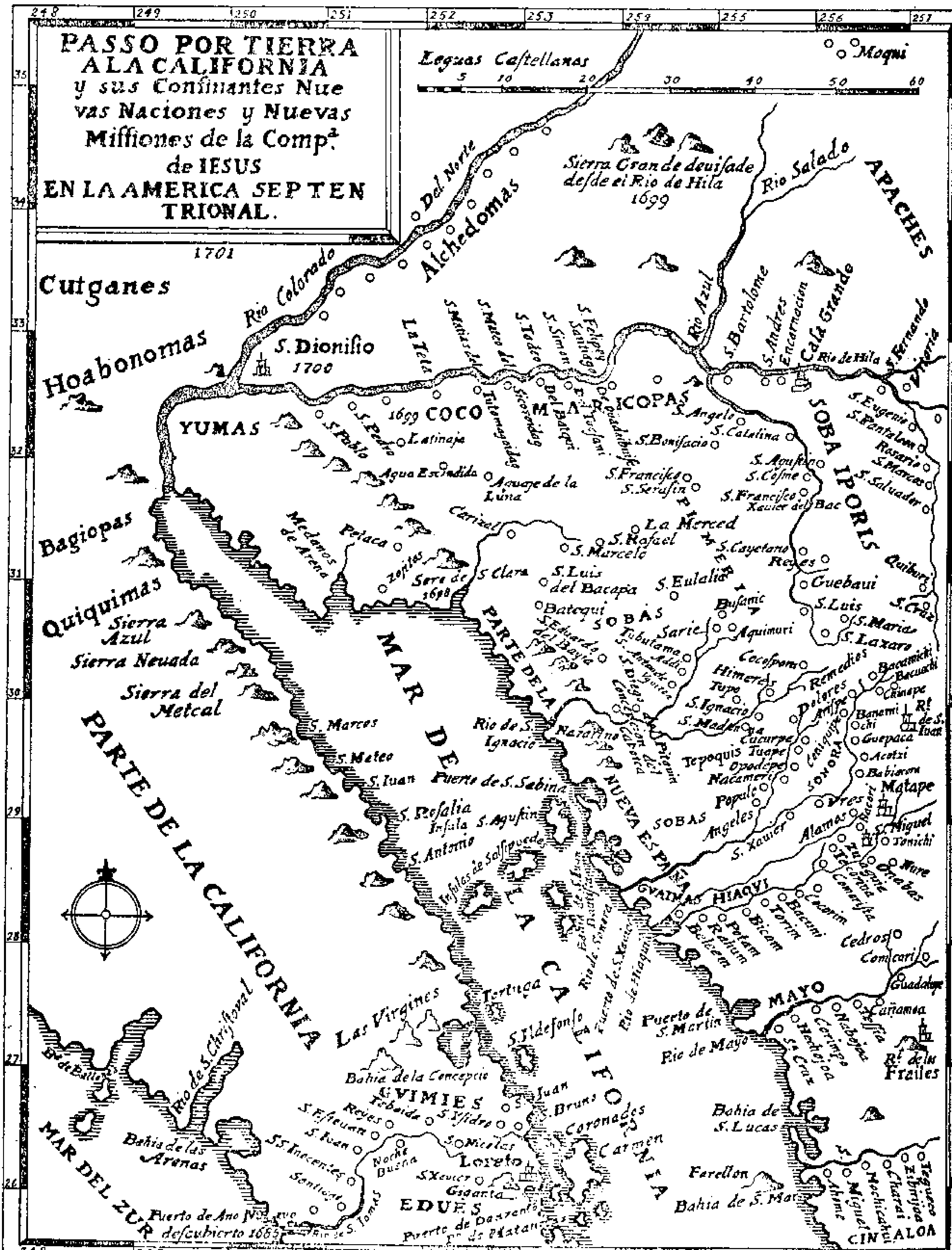
MAPS of western North America, prior to about 1700, were an unhappy mixture of fact and fancy, their content suggesting that inadequacies in available data were filled in by plagarisms from Pliny and Pedro Martyr, with a few misunderstood Indian legends included for good measure. Typical of these early maps is that by Johanum Ogiluium (John Ogilvie), circulated in England about 1680. Here we find the west coast bordered by a large body of water—the Strait of Anian—across which is the island of California. From this and other maps of about the same date, many erroneous ideas of the coastline of North America were gained. This misinformation was particularly insidious because the same maps contained many correct and easily verifiable features.

Some of these fanciful geographies can be attributed to mistranslation of Indian narratives, so that tribal mythologies were interpreted as facts; some may have been due to mirages, still common on the shores of the Vermilion Sea (now the Gulf of California); and many were just plain lies, told by travelers to impress a credulous public.

Shortly after 1705, maps of western North America suddenly changed, and the mythical Strait of Anian, in company with many other imaginary features, was no longer found between what is now Arizona and our present state of California. In its place, the Colorado and Gila Valleys are shown with considerable accuracy, and the peninsular nature of Baja California is clearly shown. D'Anville's map, "Amerique Septentrionale," published in Paris in 1746, is an excellent example of these later maps, from which "lakes of quicksilver and of gold, etc." have been eliminated.

The cited maps represent the majority opinion in their respective periods. Some earlier maps did represent California as a part of the mainland of North America; and a few later maps show it as an island. The earlier "dissenters" apparently based their opinions on unproved data, such as accounts of the explorations by Melchior Diaz (1540-41) and others; later "dissenters" chose to disregard plentiful convincing evidence.

Extensive field and library investigations disclose that most of the early maps (ca. 1700) showing Lower California as a peninsula, and Alta California (the present state) as a part of the mainland of North America, are based on the work of one man—Eusebio Francisco Kino, S.J.—who, almost single-handed, produced incontrovertible evidence that California was not an island, but a part of the mainland. This evidence is summarized in his map "Passo Por Tierra a la California," drawn in 1701. A copy of this



DRAWN 1701 BY EUSEBIO FRANCISCO KINO, S.J.

TRACED 1948 BY R.L.N.

FIG. 1

cartographic masterpiece, which is one of the most important maps in the history of North America, comprises Figure 1.[1]

So accurate is this map that no important part of it was superseded for more than a century and a half, and remapping of the entire area was not completed until the second decade of the twentieth century.[2]

Field Checking

Unlike the earlier maps of the region near the head of the Gulf of California, Kino's map shows places in their proper relation to real and identifiable natural features, so that any experienced traveller can locate the places named. When the map is used in conjunction with Kino's diaries,[3] most of the named settlements can be located within a few feet, even in the "sea of broken glass" surrounding Pinacate Volcano ("Sierra de Santa Clara," Fig. 1).

The most extensive field checking of Kino's maps has been done by Herbert E. Bolton, whose researches have made Kino's work known to the world.[4] By combining extensive library research with equally extensive field investigations, Bolton avoided most of the errors common to historical research. Studies of the western part of the area, by the MacDougal-Hornaday party (1908); by Karl Lumholtz, Alberto Celaya, and Clodomiro Lopez (1909-1910); and by the present writer (1930-1950); not only confirm Kino's site descriptions and map locations, but also verify Bolton's identifications of them. In consequence of this cross-checking, there can be absolutely no doubt that each and every location described by Kino was actually visited by him; and that Kino's "Passo por Tierra" map is based on detailed observations, some of them repeated several times to satisfy contemporary witnesses.

Fig. 1. Tracing of Kino's map "Passo Por Tierra a la California." Drawn in 1701, this map was repeatedly copied and plagarized during the ensuing century and a half.

1 Original of this map, discovered by Herbert E. Bolton, is reproduced on page 400 of his "Rim of Christendom" (New York, 1936). This tracing was made from a photostatic enlargement of the original, the blots and stains resulting from long storage being omitted, but the original pen strokes duplicated wherever possible.

2 Best modern maps are the American Geographical Society's 1/1,000,000 series of South America. Sheets pertinent here are Baja California, Norte; Baja California, Sur; Sonora; Los Angeles; and Gila River. Important basic surveys for these maps include the Narragansett survey of the Gulf of California (1873-1875), also shown on the U. S. Hydrographic Office maps of that area: the maps of the U. S.-Mexican International Boundary Commission (1891-1896); the surveys by Godfrey Sykes, published in Hornaday's "Campfires on Desert and Lava" (New York, 1909); and the surveys by Karl Lumholtz, ably assisted by Alberto Celaya and Clodomiro Lopez, published in "New Trails in Mexico" (New York, 1912).

3 Bolton, H. E. (translator and editor) *Kino's Historical Memoir of Pimería Alta,* 2 vol. ed. Cleveland, 1919: 1 vol. ed. Berkeley, 1948. This work, and various fragments of it, is also known as Kino's *Favores Celestiales.*

4 Bolton, H. E. *Rim of Chrisendom,* New York, 1936.

Kino's Training

In evaluating a map drawn two and a half centuries ago, we cannot arrive at a fair judgment by merely comparing that map with the best maps available today, for the science of cartography has not been static during the intervening years. Also, the attained accuracy of present-day maps falls far short of the accuracy attainable today, and much of the Sonoran Desert has been mapped only by the relatively crude methods used by explorers and geologists. Only by comparing the accuracy of Kino's map with the accuracy attainable by the methods known to him can we arrive at a fair evaluation of his work.

Kino's diaries, and collateral documents, disclose that he received an excellent education in the natural sciences, including advanced studies at such justly famous schools as Trent, Freiburg, Ingolstadt, Innsbruck and Oettigen. These studies, which surpassed in duration and content those now required for the degree Doctor of Philosophy, included all that was then known of mathematics, geography, and astronomy. His geographical studies, under such famous preceptors as Henry Scherer, S.J. and Adam Aigenler, S.J., gave him a mastery of cartography and navigation probably equal to any in the world at that time. It is also obvious, from his writings, that Kino was an extremely acute observer, with a wide range of interests.[5]

It is interesting to note that, in accord with accepted beliefs of the later 1600s, Kino's astronomical concepts were in accord with the Ptolemaic (geocentric) cosmography, and that, despite these (now) obsolete concepts, he was able to navigate with remarkable correctness.

Kino's Instruments and Field Methods

In the year 1700, instruments for field measurements and for navigation were few and relatively crude, yet with them it was possible to determine latitudes with great consistency, and considerable accuracy in some locations. Longitudes were determined from eclipse data, and carried forward from the point of observation by the well-known surveyor's method of latitudes and departures. Because neither distance nor elapsed time could be measured with any great accuracy in Sonora in 1700, determination of longitudes was difficult, and not very accurate.[6]

From the *Favores Celestiales* we learn that Kino's field instruments consisted of an astrolabe, for measuring angles; a mariner's compass, by which he determined directions (with a considerable error, resulting from local magnetic deviation, apparently not known to Kino); a sundial, for deter-

[5] Note description of mirage quoted in Bolton's "Rim of Christendom," p. 49.

[6] This difficulty was still serious in Sonora in 1751 (*Rudo Ensayo* p. 117) and was not fully resolved until the development of the Marine Chronometer by Harrison in 1762. Although Herne's *Method of Lunars* was first described in 1678, it could not be applied in Sonora in Kino's time because of lack of equipment for measuring elapsed time.

mining the approximate time of day; and a telescope, for viewing distant objects.

For correction of the apparent position of the sun, so that latitudes could be determined at local noon of any day, instead of only at the equinoxes, Kino used Aigenler's Tables.[7] Kino's method of determining latitudes is clearly described by him,[8] and is identical with the modern method of meridian altitudes,[9] still one of the simplest and most dependable navigational methods.

Descriptions of Kino's instruments are lacking, so that we cannot determine from direct evidence just what their construction was. However, study of typical instruments of the late seventeenth century discloses that considerable accuracy was attainable then.

Kino's astrolabe was undoubtedly an open-sight instrument, was capable of transportation in a saddle-bag, yet was fairly large, as is indicated by the accuracy of his latitude determinations. Probable diameter of the divided circle was about 12 inches, so that each degree of arc was one tenth of an inch long. Such an instrument could be read, either directly or by skilled interpolation, to about 20 minutes of arc. In consequence, the mean deviation of Kino's latitude observations should be about ten minutes of arc. An additional, but constant, error is to be expected as a result of imperfect division of the astrolabe circle, eccentricity, and misalignment of the sights with the index.

The mariner's compass, which was used by Kino to determine directions, and also to determine time, by orientation of his sundial, has changed little in the past three centuries. Its indications in 1700, and now, can be read to about half a degree of arc, but the indications will always be in error by the amount of the local magnetic declination. This error, which is hard to detect by ordinary field methods, is today about 14 degrees east of north. In 1700, it was probably less, but still east, as determined from extrapolations of the scanty data available for the area prior to 1850.

Use of a sundial to tell time is a somewhat crude method, but, in the absence of portable chronometers, not available in 1700, it was the best means available, and is accurate to about four minutes of time (local sun time, not present solar time), when the instrument is correctly oriented and levelled.

Because Kino determined latitudes by the meridian altitude method, and determined the meridian by use of a sundial, in an area where the compass probably did not point to true north, it is possible that all of his measured altitudes are in error. Computations disclose, however, that this error could

7 In Aigenler, Adam, *Tabula Geographico-horologica Universalis*—Ingolstadt, 1668. Cited in *Favores Celestiales* p. 330.

8 *Favores Celestiales,* p. 341.

9 Outlined in Bowditch, Nathaniel, *American Practical Navigator*, many editions from 1802 to 1940. See p. 158-159, revised edition of 1938, Hydrographic Office, U. S. Navy, Washington, D. C.

hardly exceed 45 minutes of arc (about 51 statute miles), and that all such errors would be positive (reported latitude value greater than actual latitude).

Kino's geological descriptions and reasoning show clearly the influence of Athanasius Kircher's *Mundus Subterraneus,* one of the important early geological works, but nowhere does Kino refer to the work directly.[10]

Kino's Map

Inspection of Kino's map "Passo por Tierra a la California" (Fig. 1) discloses that it is quite modern in appearance. Despite crudity of the drafting equipment available in Sonora in 1701, the delineation of the map is clear and firm, and the lettering, although (now) archaic, is consistent as to size, shading, and construction. North indication, scale, and coordinates are clearly shown. Detailed examination indicates that the map is the work of a trained and skillful hand, evidencing much practice.

Latitudes are shown in the modern manner, with zero at the equator and maximum (90°) at the pole. Some maps this period used co-latitudes (90°-latitude), a procedure that was already becoming obsolete in 1700, but which is still occasionally used on European maps.

Longitudes, on Kino's map, increase from west to east, contrary to modern usage in the Western Hemisphere, and start from an undesignated index which cannot be located by simple arithmetical methods.

Projection of this map is rectangular, a procedure which is quite satisfactory for the area concerned. Scaled ratio of the length of one degree of longitude to that of one degree of latitude on this map is 0.83, whereas best modern determination, at the same latitude, is 0.865. This suggests that Kino's geodetic tables were in error, probably due to their computation at a more northerly latitude.

The length of a Castilian League, as indicated on this map, is about 5.15 statute miles, as determined by comparison with the length of one degree of latitude. In 1700, the Castilian League had a length of about 3.1 statute miles. As Kino's estimated distances, in most instances, are consistent with this value, it appears that the linear scale of this map is in error.

The entire map is distorted, the skew north of Dolores being about 12° counterclockwise, and increasing as the distance from Dolores increases. This is the result of several error-causing factors, chief among which was the impossibility of determining longitudes correctly by any method available to Kino.

[10] It seems probable that Kino's contact with Kircher's work came indirectly, through Capt. Juan Mateo Manje, his military companion. Manje, who was educated in Spain, refers, in *Luz de Tierra Incógnita,* to an Atanacio Quirquerio, who wrote on geological subjects. Comparison of contexts indicates, beyond any reasonable doubt, that this "Atanacio Quirquerio" was Athanasius Kircher.

Summary of Detailed Error Analysis

As a result of the extensive field studies by Herbert E. Bolton, more than 130 of the sites indicated on Kino's map (Fig. 1) can be identified today. More than half of the townsites mapped by Kino are still occupied, and retain, in 1950, names similar to those used in 1700. More than 100 of these sites have been checked by either Carl Lumholtz or the present writer, furnishing a rigorous verification of many of Bolton's identifications.

By comparing the geographical positions of these sites, as determined from the best available modern maps, with those scaled from Kino's map, the error[11] in each position can be determined.

Because Kino's latitude determinations were instrumental, and their number is great, that latitude errors can be investigated statistically to determine their probable type and cause. Important derived figures here are *average error* and *mean deviation*.[12] In a study of this type, instrumental defects, such as index error, show as average error, which will be zero if there are no consistent defects in the instrument; and observer defects, such as "personal error" (which all observers have, no matter what their skill), will appear as mean deviation, as also will inconsistent instrumental defects, such as loose pivots, bearing friction, and warpage of scales.

When the latitude errors of the entire map are considered, the average error is—11.2 minutes of arc, and the mean deviation 25.01 minutes. When the assumed index error of—11.2 minutes is compensated for, the mean deviation decreases to 20.3 minutes of arc. This is equal to an error of 1/30th of an inch in reading the scale of a 12-inch astrolabe!

Consideration of the magnitudes of the errors in various zones of the map discloses that nearly all of the errors north of (Kino's) latitude 29° are negative; while those south of the 29th parallel are positive. This suggests that a change in the instrument used, or in the observer, took place when the 29th parallel was crossed. If only the instument was changed, either by damage, readjustment, or substitution, the mean deviation, largely due to observer defects, should remain about the same, whereas if both instrument and observer were changed, a change in both average error and mean deviation could be expected.

Statistical investigation discloses that for those observations north of Kino's 29th parallel the average error is—27.6 minutes of arc; and the mean deviation, after correction of the index for the average error, is 9.09 minutes. This amounts to an error of scale of only about 1/60th of an inch on a 12

[11] The term *error* is here used in the objective sense, with no stigma implied or intended, to designate a difference between the location as scaled from Kino's map and that determined from modern surveys. When Kino's value is numerically smaller than that now accepted, the error is designated as negative: when Kino's value is greater than the modern value, the error is designated as positive.

[12] Average error is the algebraic sum of all the errors, divided by the number of errors. Its algebraic sign may be either positive or negative. Mean deviation is the average of the sum of the absolute values of the errors, and is always considered positive.

inch astrolabe, and is about as close as any ordinarily skilled observer, now or in 1700, can read!

South of Kino's 29th parallel, the average error is +19.7 minutes of arc, and the mean deviation, after correction for the supposed index error, is 14.4 minutes. This is equivalent to an error of about 1/40th of an inch in reading a 12-inch astrolabe.

From this investigation of errors, it appears probable that the instrument used north of the 29th parallel was not the same as that used south of it on the mainland; and that Kino probably did not make the observations in the southern part of the area, along the Mayo and Fuerte Rivers. Statistical investigation of the observations from the La Purísima area of Baja California, where Kino definitely did make observations, is not possible because of the relatively small number of his observations, and the lack of good modern data for comparison purposes. Although a jeep trail now follows Kino's approximate route across Baja California, and the sites of his camps can be located within a few thousand feet, in most instances, these locations have not yet been "tied in" to a major geodetic network, so that field checking, using instruments not much better than Kino's, discloses only that the original observations are within reason.

The longitudes on Kino's map were determined subjectively, by estimate, and hence are not suitable for statistical review. Furthermore, the longitudes are patently wrong, but consistently so. Because Kino was a trained geographer, who followed his field methods consistently year after year, there is some hope that the causes of these errors can be located.

As previously noted, the longitudes are numbered eastward from an undesignated index. Kino places the junction of the Gila and Colorado Rivers at long. 250°. The meridian 250° west of this point passes suggestively close to Madrid, Spain! Because Mexico, in 1700, was Spanish territory, use of Madrid as an index is not unreasonable.

A second check, however, using Mission Dolores, Kino's "home base," 255°46′ east of the index, places the index meridian at 6°23′ west of Greenwich. This meridian passes through the isles of Lewis and Skye, eastern Ireland, and western Spain, assiduously avoiding all major centers of geographic learning and important observatories. In consequence, it appears that Kino's index meridian did not pass through Madrid.

Scaled ratio of one degree of longitude to one degree of latitude, at 30° N., on Kino's map, is 0.83, whereas the best modern determination, at the same latitude, is 0.865. This suggests that Kino's geodetic tables were either in error or erroneously used. If the longitudes cited by Kino are corrected for this error (by dividing by 1.04), the extrapolated positions of the indices bracket the Canary Islands, through which the prime meridian of many maps drawn in 1700 passed. It is notable that the prime meridian of Aigenler's maps, and of Riccioli's Tables, both used by Kino, passed through Tenerife in the Canary Islands.

Although the length of a degree of longitude, in Castilian leagues, as used by Kino, is incorrect for latitudes near 30° North, and is exactly correct for the latitude of Copenhagen, Denmark, Kino's distances in Castilian leagues (approx. 3.1 statute miles of 5280 feet), are correct within about five percent for east and west directions. Further checking discloses that Kino's local index for longitude was probably Mexico City, and that its position was determined from Riccioli's Tables ("Messico in Nova Hisp. 20°40′ N.; 277° E".) This position was too far north and too far east, but the error is relatively slight.

As nearly as can be determined from a study of the literature, this location was carried forward, largely by estimated departures, from Mexico City to the Valley of the Rio de Sonora by several field workers, of varying competencies, and the location of Mission Dolores determined from the resultant figure, with its cumulated errors. From this site, Kino carried the observations forward, by estimated leagues of departure, to the mouth of the Colorado River. Distance errors in Kino's work are less than five percent. Index errors are great, due to primary mislocation of the index used, and later to use of a degree of longitude which was about 0.73 of the correct length. The problem of longitudes was still serious in 1751, and was not finally resolved until after 1800 in this area.

From this investigation of the errors in Kino's map it appears that his latitude measurements were about as good as can be secured with the instruments available to him. Any modern observer who can measure more than 100 latitudes with a portable open-sight instrument and have a mean deviation of less than 10 minutes of arc is entitled to take considerable pride in his accomplishement. The mean deviation of the observations directly attributable to Kino is 9.09 minutes.

East-west distances in Kino's map, based on estimates, come within about five percent of the modern values. When it is realized that the observations were spaced over several decades, and that there was no satisfactory method of checking closure of the traverses, this accuracy is rather remarkable. Errors in longitude designations, due to an initial error in the location of Kino's index, and to a second error in determining the length (in leagues) of a degree of longitude, are unfortunate, but common to the "state of the art" in 1700, and of very little real importance because the errors within the map are quite consistent.

Geographic Value of Kino's Map

Kino's famous map "Passo por Tierra a la California" (Fig. 1), was reprinted many times in Europe during the half century after its completion. Some of the reprintings gave credit to the author, more merely "pirated" the findings. As a result of Kino's work in the northern parts of Mexico and the southwestern United States, the legend of the Strait of Anian, and of the Island of California, was replaced by sound geographical knowledge.

During the major part of the eighteenth century, when the Spanish possessions of New Spain and of California were being integrated, this map was the only one available which showed, dependably, the locations of the missions, towns, and water holes in the lands of the Pimas, Papagos, and Yumas. Much of the work of Jacob Sedelmayr; and the trail-finding of Juan Bautista de Anza, depended upon this map. In 1776, Juan Bautista de Anza led a group of pioneers from lower Sonora across this area to California, where the town of Yerba Buena (now San Francisco) was founded. During the previous year, using Kino's trail data, De Anza scouted out the best route for his party, so that, when the major migration was attempted, the trail was not lined with graves.

For considerably more than a century, Kino's map was the only dependable one of this area, and today, even though the art has advanced considerably, it is possible to navigate by it with no serious difficulty.

When it is realized that this map locates some of the most barren and inaccessible parts of North America, and that it was made under physical and technical conditions of two and a half centuries ago, its accuracy is remarkable, indicating that Kino, the "Apostle to the Pimas," was not only a competent missionary and administrator, but also one of the leading explorers, geographers, and cartographers of his time.

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