THE REPUBLIC OF GHANA

Based on archaeological evidence, it has been established that Ghana was inhabited by humans 300,000 years ago. By 2,000 B.C., domesticated animals such as cattle and guinea fowl were being raised. Modern Ghana takes its name from the ancient Kingdom of Ghana, some 800 km to the north of the present-day capitol of Accra, which flourished up to the eleventh century A.D. In 1471, the Portuguese arrived at the "*De Costa da el Mina de Ouro*," (the Coast of Gold Mines). In 1486, slaves from Benin were introduced to the port of Elmina. This was the beginning of the slave trade on the Gold Coast, and eventually the more profitable slaves replaced the gold trade. The British Crown Colony of the Gold Coast received its independence from England in 1957.

The Republic of Ghana lies on the western coast of tropical Africa. Ghana extends for a maximum of 672 km from north to south between latitudes 4.5°N and 11°N, and for 536 km east to west between longitudes 3°W and 1°E. It is bordered to the west (668 km) by Cote d'Ivoire (Ivory Coast), to the north (548 km) by Burkina Faso, to the east (877 km) by Togo, and to the south (539 km) by the Gulf of Guinea and the Atlantic Ocean.

On May 21, 1929 Capt. J. Calder Wood, M.C. of the Gold Coast Survey Department wrote: "In June, 1904, observations for latitude were taken by Capt. F. G. Guggisberg, R.E. (now Sir F. G. Guggisberg, K.C.M.G., D.S.O., Governor of the Gold Coast Colony), from a pillar in the compound of the house of the Secretary for Native Affairs in Accra. Fifteen pairs of stars were observed with a zenith telescope, giving a final probable error of 0.360". This point was subsequently connected by traverse to the Gold Coast Survey beacon No. 547 in Accra. The longitude of Accra was determined by the exchange of telegraphic signals with Cape Town in November and December, 1904, and the resulting longitude of G.C.S. 547 obtained."

"The pillar G.C.S. 547 was connected to the pillar at Leigon, eight miles from Accra, by means of triangulation, and the resulting values of the Leigon pillar have been adopted as the basic latitude and longitude for the Colony. Subsequent determinations of latitude during the last two years at points throughout the country which have been accurately connected with Leigon by triangulation tend to indicate that the latitude and longitude observations taken at Accra are seriously influenced by local attraction. The conditions obtained near the Coast do not appear to be reproduced further inland, and it may happen in course of time, when more data are available, that a new basic latitude and longitude will be adopted from inland observations which will give a better datum point for the county as a whole. Sufficient comparison between the astronomical and trigonometrical, or geodetic, values have not yet been obtained to warrant an immediate change."

The astronomical values observed for (G.C.S. 121) Leigon were: Φ_o = 5° 38' 54.39" North, and λ_o = –0° 11' 52.65" West of Greenwich. The corresponding geodetic coordinates of the same Accra Datum of 1929 origin point that were computed from the triangulation were: ϕ_o = 5° 38' 52.270" North, and λ_o = –0° 11' 46.080" West of Greenwich. In 1928, as other observations were being taken at Leigon, it was decided to observe an azimuth there to test an intermediate side of the triangulation. The azimuth observed from Leigon to station (G.C.S. 113) Asofa was: α_o = 264° 48' 48.78". The ellipsoid of reference is the War Office 1926 (McCaw 1924) where a = 6,378,300 meters (20,926,201.2257 feet), and 1/f = 296. Note that this conversion from feet to meters is specific to Ghana, and the elevation of Leigon is 147.46 meters. As of late 1996, the transformation parameters from Accra Datum of 1929 to WGS 84 Datum were based on three collocated points where: ΔX = –199 m, ΔY = +32 m, ΔZ = +322 m.

Capt. Wood continued, "For the purposes of cadastral work geographical coordinates are inconvenient, and in their place plane rectangular coordinates on the transverse mercator (sic) projection have been adopted. The whole Colony has been placed on the same origin, the central meridian being the meridian 1° W and the origin of the X coordinates 4° 40' N. 900,000 is added to all Y coordinates, in order to avoid negative coordinates, and the maximum scale error has been reduced in the customary manner by reducing the scale of the projection by 1/4000, so that the scale error nowhere exceeds this value except on the extreme edges of the Colony."

For instance, "Leigon (G.C.S. 121). District Accra. Locality west of road junction at 8th mile Acra-Dodowa road. Approach through low bush from junction of Aburi and Dodowa roads. Bare hill with good all round view. Concrete pillar 14" high by 9 1/2" by 7" with iron pipe as centre mark. Beacon double

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quadripod of squared timber, 17' high, centered over old mark." The geodetic coordinates of Leigon equate to Colony coordinates of X = 356,084.33 ft., Y = 1,192,117.91 ft. As I always point out; if your double- or quadruple-precision software does not exactly match the local transformation results, your software is wrong for that country. Colony coordinates are truncated Gauss-Schreiber Transverse Mercator transformations that are similar to those used in the United States for the NAD 1927 State Plane Coordinate Systems. They are not computed the same way as the Gauss- Krüger Transverse Mercator transformations normally done with other Grid systems such as the UTM and the NAD 1983 State Plane Coordinate Systems.

According to J. Clendinning in *Empire Survey Review*, January 1934: "The Akuse-Obuasi, Obuaasi-Nsuta and Akuse-Apam chains were computed in terms of geographical coordinates which were later converted into rectangular coordinates on the projection system; but all recent work, both triangulation and traverse, has been computed directly on the projection system, the necessary corrections to distances and bearings as measured on the ground being applied to enable this to be done." In that same paper, Clendinning also commented on the surroundings of the Gold Coast in that "The denseness of the forest and the topographical features of the country naturally determine the nature of the survey." With that terrain in mind for Ghana, the *Textbook of Topographical Surveying*, Her Majesty's Stationery Office, London, 1965, pp. 221, 222 offered the following description:

"311. The rope and sound traverse

In West Africa, the minor bush tracks maintain their general direction for considerable distances but wind about just sufficiently to prevent a sight being taken down the track. A system of survey which has been used in these conditions is as follows. The bearings of the traverse legs are observed from a compass station to sound. This sound may be either a call or a whistle from a forward chainman. The length of the legs is measured with a rope. This rope is made of a length allowing for the wind in the path. Thus it is normally found that a rope 310 ft. long pulled tight along the path is equivalent to 300 ft. measured direct along the leg of the traverse. The actual allowance must be found by experience of local conditions. The length of the rope should be checked and adjusted before and after work and in the middle of the work.

Using this system, minor bush tracks can be traversed rapidly and it is possible to work through trackless bush doing only a minimum amount of cutting. When undergrowth is thick or thorny a shorter rope (100 ft.) may be easier to manipulate. The accuracy of this work is greater than would be expected. There appears to be no systematic error in the observations of bearing and the errors consequently tend to cancel out during the traverse. For work at a scale of 1/125,000, traverses should not be carried for more than five miles by this method. Heights are observed by aneroid barometers. On the Gold Coast, an average of five miles per day can be maintained, and distances of 15 miles have been achieved on single days. If, however, work is continued into the afternoon, as is necessary for such an output, it is necessary to re-run later that part of the aneroid heights which was observed in the period when the diurnal wave is unreliable."

In the Canadian cartographic journal, a letter to the editor told how they were cutting costs by eliminating the forward chainman. "They tied the rope to the tail of a pig and sent it down the path. When the rope became taut, the tail of the pig was pulled and it squealed so they could observe a bearing on that sound. They were working on further improving the method by breeding a special pig that would, in addition, monument the spot when its tail was pulled."

In 1977, the control network was readjusted including extra observations and an improved computation technique. As part of the readjustment the datum was changed. The new Datum was Leigon Datum of 1977, in which the old geographical values for (GCS 121) Leigon were held fixed at the old values and the War Office ellipsoid was replaced by the Clarke 1880 (modified) ellipsoid where a = 6,378,249.145 meters, and 1/f = 293.465. The False Easting was changed to 274,319.736 m. In 1991, the National Imagery and Mapping Agency (NIMA) published the three-parameter datum shift values from Leigon Datum of 1978 to WGS 84 based on eight collocated points where: $\Delta X = -130$ m. ± 2 m., $\Delta Y = +29$ m. ± 3 m., $\Delta Z = +364$ m. ± 2 m. Out of curiosity, I decided to try an 8-point solution for a 7-parameter Bursa-Wolf shift from Leigon Datum of 1977 to WGS 84 Datum. The resultant was $\Delta X = -110.90$ meters, $\Delta Y = -9.13$ meters, $\Delta Z = +69.46$ meters, Scale = $+3.11 \times 10^{6}$, $R_x = -1.30$ arc seconds, $R_y = +9.53$ arc seconds, and $R_z = +0.32$ arc seconds. The increase in goodness of fit was about ten-fold over the 3-parameter solution. An example data point is station (G.C.S. T20/24) "Wa" on the Leigon Datum of 1977 where: $\phi = 10^\circ$ 02' 47.7770" North, and $\lambda = -2^\circ$ 28' 17.3746" West, and a MSL elevation of 359.7 meters with coordinates of "Wa" on the WGS 84 Datum where: $\phi = 10^\circ$ 02' 56.3328" North, and $\lambda = -2^\circ$ 28' 16.6377" West and an ellipsoid height of 385.1 meters. Of course, on the WGS 84 Datum the coordinates are expressed on the UTM Grid, and not on Colony Coordinates.