



GRIDS & DATUMS

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The Grids & Datums column has completed an exploration of every country on the Earth. For those who did not get to enjoy this world tour the first time, *PE&RS* is reprinting prior articles from the column. This month's article on the Federal Democratic Republic of Ethiopia was originally printed in 2003 but contains updates to their coordinate system since then.

Ethiopia, occasionally called Abyssinia, is an ancient country in Northeast Africa. It is bounded on the north by Eritrea (912 km), on the east by Djibouti (337 km) and Somalia (1,626 km), on the south by Somalia and Kenya (830 km), and on the west by Sudan (1,606 km). Ethiopia has an area slightly less than twice the size of Texas, it is landlocked, and is mainly high plateau with a central mountain range divided by the Great Rift Valley. The lowest point is Denakil (-125 m), and the highest point is Ras Dashen Terara (4,620 m). Modern Ethiopia began with the reign of Tewodros II and the conquest of other chiefs in 1855. Later coming under Italian rule in 1882 and claimed as an Italian Protectorate by the Treaty of Ucciali in 1889, the coastal region was made a separate Italian Colony in 1890 and named Eritrea. Territorial integrity of Ethiopia was recognized by Great Britain, France, and Italy in 1906. Invaded by the Italians in 1935, and organized with Eritrea and Italian Somaliland as the Empire of Italian East Africa, the region was liberated by the British in 1941. The new constitution was adopted in 1987. Ethiopia's entire coastline along the Red Sea was lost with the *de jure* independence of Eritrea on 27 April 1993.

Very little mapping was done of Ethiopia in the 19th century. One of the earliest investigations of the region resulted in a "Report of the German Expedition to East Africa, 1861 and 1862," published in 1864 by Munzinger. The British explorer, Sir Samuel Baker, wrote of the region in 1867 in "The Nile Tributaries of Abyssinia." The Italians made some ground surveys in the region of Eritrea from 1888 to 1891, and these surveys formed the basis of the old *Carta della Colonia Eritrea* (Map of the Colony of Eritrea) at a scale of 1:50,000 which was published from 1909 through

FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA



1938. Another series was also published during the same time by the Italians at a scale of 1:100,000. New surveys of 1935 through 1938 resulted in one sheet being compiled on a Santoni stereoplotter with 50-meter contours. Smaller scale series were derivative compilations at the time.

The Ethiopian Datum of 1936 was established by the Italians at the West End of Metahara Base (10,083.560 m) where $\Phi_0 = 8^{\circ}53' 22.53'' \pm 0.18''$ N, $\Lambda_0 = 39^{\circ}54' 24.99''$ East of Greenwich, the reference azimuth to Monte Fantalli was $\alpha_0 = 13^{\circ}05' 21.97'' + 0.43''$, and the presumed ellipsoid of reference was the International 1924 where $a = 6,378,188$ m and $1/f = 297$. The check base for the chain commencing at Metahara was Giggiga base, which was 12,962.620 m in length. Halfway north from Metahara base to the now Eritrean port city of Massawa was the North End of Alomalà base (18,211.982 m) where $\Phi_0 = 12^{\circ}24' 56.56'' \pm 0.13''$ N, $\Lambda_0 = 39^{\circ}33' 30.42'' \pm 0.30''$ East of Greenwich, and the reference azimuth to the South End of Alomalà base was $\alpha_0 = 180^{\circ}00' 03.88'' \pm 0.18''$. The old Italian 1:50,000-scale series mentioned above is based on the old datum origin located in the (now) Eritrean capitol city of Asmara. The coordinates of that origin elude me, and I suspect that the observations

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may have been made by the Italian navy rather than by the Istituto Geografico Militare of Firenze (Florence). In any case, there was no grid printed on any of the above series, even though the cartographic and geodetic work was done by the Italian military!

The Blue Nile River Basin Investigation Project was funded by the United States, and the geodetic work was performed by the U.S. Coast & Geodetic Survey. The origin of the geodetic work was in southern Egypt near Abu Simbel, south of Lake Nasser, at station Adindan where $\Phi_0 = 22^\circ 10' 07.1098''$ N, $\Lambda_0 = 31^\circ 29' 21.6079''$ East of Greenwich, the deflection of the vertical $\zeta = +2.38''$ and $\eta = -2.51''$, and the ellipsoid of reference was the Clarke 1880 (modified) where $a = 6,378,249.145$ m and $1/f = 293.465$. The Blue Nile Datum of 1958 appears to be the established classical datum of Ethiopia and much of North Africa. Adindan is the name of the origin, it is not the name of the datum; a most common mistake found in many "reference works." The Ethiopian Transverse Mercator grid is based on a central meridian where $\lambda_0 = 37^\circ 30' E$, scale factor at origin where $m_0 = 0.9995$, False Easting = 450 km, and False Northing = 5,000 km.

Ethiopia and Kenya signed a boundary treaty on 09 June 1970, and the field surveys for the demarcation of the border were performed by British surveyors. The datum used for

that survey was the Arc 1960 Datum, referenced to the Clarke 1880 (modified) ellipsoid. The grid system used at the time was the East Africa Transverse Mercator Belts H, J, and K where the central meridians are $\lambda_0 = 37^\circ 30' (H)$, $42^\circ 30' (J)$, and $47^\circ 30' (K)$; the scale factors at origin are all where $m_0 = 0.9995$, all False Eastings = 400 km, and False Northings = 4,500 km.

An International Boundary Commission has been formed by the United Nations to establish and demarcate a boundary between Ethiopia and Eritrea. The boundary has been researched and established, but the demarcation remains to be performed at the present time. The 125-page document published by the United Nations in April 2002 makes for some fascinating reading. The datum of record of the Commission is the WGS84, and will be used for the demarcation survey someday.

There are two sets of parameters published by NIMA for transforming from the Blue Nile Datum of 1958 to the WGS84 Datum: the mean solution for Sudan and Ethiopia is based on a 22-station solution where $\Delta X = -166\text{m} \pm 5\text{m}$, $\Delta Y = -15\text{m} \pm 5\text{m}$, and $\Delta Z = 204\text{m} \pm 5\text{m}$. The solution for Ethiopia is based on an eight-station solution where $\Delta X = -165\text{m} \pm 3\text{m}$, $\Delta Y = -11\text{m} \pm 3\text{m}$, and $\Delta Z = +206\text{m} \pm 3\text{m}$.

Ethiopia Update

A 2019 thesis covers a detailed analysis of datum transformations in the northwest area of Ethiopia, but has no new data points, just more elaborate math models:

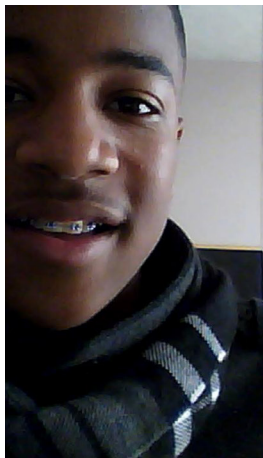
- Determination of Parameters for Datum Transformation between WGS 84 and ADINDAN-Ethiopia, Hassen, A. M.
- <http://etd.aau.edu.et/bitstream/handle/123456789/23487/Abubeker%20Mohammed.pdf?sequence=1&isAllowed=y>

As referenced in the original column, the United Nations has now published some boundary monuments in a report:

- Eritrea-Ethiopia Claims Commission - Statement by the Eritrea-Ethiopia Boundary Commission with Annex (List of Boundary Points and Coordinates) 27 November 2006.
- https://legal.un.org/riaa/cases/vol_XXVI/771-799.pdf

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