

# Grids & Datums

## REPUBLIC OF PERÚ

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The seat of the Inca Empire was established in Cuzco, Perú about 1230 AD, and by the mid-15th century, ruled parts of Colombia (PE&RS November 1997), Ecuador (PE&RS May 1999), Perú, Bolivia (PE&RS July 2001), Chile, and Argentina (PE&RS December 1999). The Spaniard Francisco Pizarro conquered the Incas in 1533 with the help of Diego de Almagro. Lima was founded in 1535, and initially became the seat of the Viceroyalty of Perú. The Argentinean leader, José Francisco de San Martín, declared the Peruvian independence from Spain in 1821 and remaining Spanish forces were defeated in 1824. (Webster's Geographical Dictionary)

Perú borders Bolivia (900 km), Brazil (1,560 km), Chile (160 km), Colombia (1,496 km), Ecuador (1,420 km), and the Pacific Ocean (2,414 km). Perú is slightly smaller than Alaska, with its lowest point at the Pacific Ocean (0 m), and the highest point at Nevado Huascarán (6,768 m); the terrain is comprised of the western coastal plain (costa), high and rugged Andes in the center (sierra), and the eastern lowland jungle of the Amazon Basin (selva). The climate varies from tropical in the east to dry desert in the west; it is temperate to frigid in the Andes mountain range.

*La Cartografía Nacional* was established in 1859 when the President of the Republic, Don Ramón Castilla, placed don Mariano Felipe Paz in charge of preparing a general map of Perú. From 1901 to 1909, a geodetic chain of triangulation was surveyed from Viviate to Piura by consulting French Army Officers with the intention of accomplishing a meridional arc of high precision in the equatorial region. In 1904, Lieutenant Colonel Pablo Berthon of the Misión Militar Francesca organized a topographic section of the Military Academy in Chorrillos. On 06 March 1906, President José Pardo approved the topographic service. Numerous topographic sheets were compiled by planetable and alidade of Lima, Ancón, and Tumbes, the latter probably based entirely on the previous chain observed by the French Army Officers. In 1912, the name was changed to the *Servicio Geográfico del Ejército* (Army Geographic Service), and the Major General and Chief of Staff of the Army ordered fieldwork extended into the areas of Puno, Moquegua, Canta, and Chiclayo. In 1916, the *Servicio Geográfico* was reorganized under one Director with a topographic section and a cartographic section. The work then concentrated on topographic fieldwork (by planetable and alidade) of nine sheets of Arequipa at a scale of 1:200,000, and was based on a geodetic network referenced to the Clarke 1880 ellipsoid where:  $a = 6,378,249.145$  meters, and  $1/f = 293.465$ . These were also the first Peruvian maps to be printed in color.

On 10 May 1921, the National Map of Perú was commenced by planetable and alidade methods, and the ellipsoid of reference for the rest of the 20th century was changed to the International (Hayford 1909) where:  $a = 6,378,388$  meters,  $1/f = 297$ . The National Map of Perú was to be compiled at a scale of 1:200,000, based on the Greenwich Prime Meridian, and the projection was to be the Polyhedric. The reader may recall that the ellipsoidal Polyhedric projection can

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be easily approximated by the “Local Space Rectangular” projection when constrained to a plane. (See the Manual of Photogrammetry, 5th edition). The plan was to produce 261 map sheets that were cast on a standard graticule of 48' of latitude and 36' of longitude.

On 02 February 1944 the name of the organization was changed to *Instituto Geográfico Militar (IGM) del Perú*. In 1957, IGM was authorized to change compilation methods to employ aerial photography and stereophotogrammetry to continue with the National Map. On 09 April 1958, IGM initiated photogrammetric operations with negatives flown by the Inter American Geodetic Survey (IAGS) of the U.S. Army Map Service. The new specification for mapping was to be based on the Provisional South American Datum of 1956 with origin in the town of La Canoa, Anzoátegui Province, Venezuela where  $\Phi_0 = 08^\circ 34' 17.170''$  North,  $\Lambda_0 = -63^\circ 51' 34.880''$  West of Greenwich, and the defining azimuth to station Pozo Hondo ( $\alpha_0$ ) =  $40^\circ 22' 45.96''$ . The standard sheets were to be at 1:100,000 scale, cast on the UTM grid, and the graticule was to be 30' of latitude and 30' of longitude. The vertical datum was defined as mean sea level.

With the cooperation of the IAGS, a concerted campaign of geodetic

*continued on page 496*

triangulation was commenced that included the following chains with lengths and positional errors at the terminal points: Tarqui – Piura (225 km), 1:352,000; Piura – Chimbote (450 km), 1:273,000; Chimbote – Salinas (250 km), 1:309,000; Salinas – Conchan (125 km), 1:321,000; Conchan – Marcona (360 km), 1:324,000; Huancayo – Pucusana – Pucara (150 km), 1:333,000; Cerro de Pasco – San Francisco – Chonta (150 km), 1:789,000; Marcona – Majes (310 km), 1:310,000; Majes – Sama (225 km), 1:336,000; Sama – Chaca (120 km), 1:300,000; Puquio –Huahupasa – Huancaramis (140 km), 1:237,000; Cerro Apopata – Camane Avabacas (140 km), 1:269,000; Ayabacas – Anta (300 km), 1:283,000; Anta – Ayacucho (240 km), 1:202,000; Ayacucho – Huancayo (175 km), 1:438,000; and Pichus – Cerro Jampito – Cerro de Pasco (125 km), 1:291,000. (DMATC GM No. 1684) In 1980, the agency name was changed to Instituto Geográfico Nacional.

The old transformation from NWL9D (WGS72) to PSAD56 for Perú expressed with 7 parameters are as follows:  $\Delta X = +282.57$  m,  $\Delta Y = -185.85$  m,  $\Delta Z = +401.38$  m,  $dS = -2.69414 \times 10^5$ ,  $R_x = -0.31989^\circ$ ,  $R_y = -0.39589^\circ$ ,  $R_z = +2.29014^\circ$ . The new 3 parameter transformation from PSAD56 to WGS84 as published in 1991 by the now obsolete NIMA/NGA TR 8350.2 is:  $\Delta X = -279$  m  $\pm 6$  m,  $\Delta Y = +175$  m  $\pm 8$  m,  $\Delta Z = -379$  m  $\pm 12$  m, and was based on 6 collocated points. Curiously, IGN published different parameters from WGS84 to PSAD56 in 2005 as follows:  $\Delta X = 303.55$  m,  $\Delta Y = -265.41$  m,  $\Delta Z = +358.42$  m. Note that the datum shift direction is different than that published by NIMA/NGA, and that the Peruvian-published parameters do not have an associated accuracy statement. Transformation parameters have been offered by the U.S. Military for Perú that utilize the South American Datum of 1969, but there seems to be zero recognition of that relationship (or use) by Perú.

In addition to the standard UTM Grid used for mapping associated with military applications, there are four Transverse Mercator Grid systems used in Perú. The First three are on the PSAD56. The Perú Transverse Mercator East Zone is defined by a Central Meridian ( $\lambda_o$ ) =  $-70^\circ 30'$  West of Greenwich, Latitude of Origin ( $\phi_o$ ) = Equator, False Northing Latitude of Origin ( $FN\phi_o$ ) =  $-9^\circ 30'$  South, Scale Factor at Origin ( $m_o$ ) = 0.999933, False Easting = 1,324,000 m, and False Northing = 1,040,084.558 m. The Perú Transverse Mercator Central Zone is defined by a Central Meridian ( $\lambda_o$ ) =  $-76^\circ 00'$  West of Greenwich, Latitude of Origin ( $\phi_o$ ) = Equator, False Northing Latitude of Origin ( $FN\phi_o$ ) =  $-9^\circ 30'$  South, Scale Factor at Origin ( $m_o$ ) = 0.999933, False Easting = 720,000 m, and False Northing = 1,039,979.159 m. The Perú Transverse Mercator

West Zone is defined by a Central Meridian ( $\lambda_o$ ) =  $-80^\circ 30'$  West of Greenwich, Latitude of Origin ( $\phi_o$ ) = Equator, False Northing Latitude of Origin ( $FN\phi_o$ ) =  $-6^\circ 00'$  South, Scale Factor at Origin ( $m_o$ ) = 0.999933, False Easting = 222,000 m, and False Northing = 1,426.834.743 m. The Perú International Petroleum Company (IPC) Transverse Mercator (27 October 1950) is defined by a Central Meridian ( $\lambda_o$ ) =  $-74^\circ 38' 03''$  West of Greenwich, Latitude of Origin ( $\phi_o$ ) = Equator, False Northing Latitude of Origin ( $FN\phi_o$ ) =  $-9^\circ 08' 08''$  South, Scale Factor at Origin ( $m_o$ ) = unity, False Easting = 870,000 m, and False Northing = 1,080,000 m. The IPC Grid is obviously on an ersatz datum (a technical term for “baloney”), because the ellipsoid of reference is the Clarke 1866, and is obviously something cooked up with the wrong set of projection tables! (That’s not unheard of, especially when a geodesist has had to “winter over” on a remote island and forgot to pack the proper book of tables.) Ayabacas Base and Sama River Base are the names of two datums that apparently were old “astro” stations observed in a past century, probably the 20th.



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