CHAPTER II

RELATED THEORY

This problem describes the coordinate reference system, geodetic datum , and projection. It describes the method for determining references on topographic map (1:50,000 scale, Edition 2-RTSD series L7017) and larger scale maps such as geological map of Thailand (1:500,000 scale, Geological survey Division, Department of Mineral Resources,1983Edition, Editing Committee: Dr.Chonglakmani,C.,Dr. Bunopas,S., Charoenpravat,A., Nakinbodee, V.,Nakornsri,N.,Dheetadilok, P., and Sarapirome,S.) , and Geology of Burma (1:2000,000 scale, Friedrich BENDER with Contributions of Dietrich BANNERT, Jorn BRINCKMANN, Franz GRAMANN and Dietrich HELMCKE 1981, Compiled by D.Bannert and D.Helmcke). Topographic map contains identifications for the zone number 47 north designations and for the meter unit of the Universal Transverse Mercator Grid. It provides diagrams and textual information for delineating geodetic datums and ellipsoids.

Region/ Country	Area of use	Coordinate System	Projection	Geod. Datum	Ellipsoid	Zone	Unit
Thailand	Thailand - west of 102 deg East.	Indian 1975 / UTM zone 47N	Transverse Mercator	Indian 1975	Everest 1830 (1937 Adjustment)	UTM zone 47N	metre
Myanmar; Thailand	Myanmar (Burma) - east of 96 deg East; Thailand - west of 102 deg East.	Indian 1954 / UTM zone 47N	Transverse Mercator	Indian 1954	Everest 1830 (1937 Adjustment	UTM zone 47N	metre
New Map	Myanmar (Burma) - east of 96 deg East; Thailand - west of 102 deg East.	WGS84/UTM Zone47N	Transverse Mercator	World Geodetic System 1984	WGS 84	UTM zone 47N	metre

Table-2.1. Region of Use Datum List

2.1. Projection and Coordinate

Map projections are attempts to portray the surface of the earth or a portion of the earth on a flat surface. Some distortions of conformality, distance, direction, scale, and area will always result from this process. Some projections minimize distortions in some of these properties at the expense of maximizing errors in others.

Universal Transverse Mercator (UTM) coordinates define two dimensional, horizontal positions. UTM zone numbers designate 6 degree longitudinal strips extending from 80 degrees South latitude to 84 degrees North latitude. There are 60 of these 6 degree strips. This makes sense since 6 times 60 equals 360 degrees. Additionally, although not always used, the UTM zone designator includes a letter to help identify northern and southern hemispheres. These letter designators are 8 degrees apart extending from 80 degrees South latitude to 84 degrees North latitude lettered from A-X (omitting I and O).

Each zone such as zone has a central meridian. Zone 47 on figure 2.1. for example, has a central meridian of 99 degrees east longitude. The zone extends from 96 to 102 degrees east longitude. Eastings are measured from the central meridian (with a 500km false easting to ensure positive coordinates). Northings are measured from the equator beginning a 0 meters up to 10,000km for locations in the northern hemisphere.

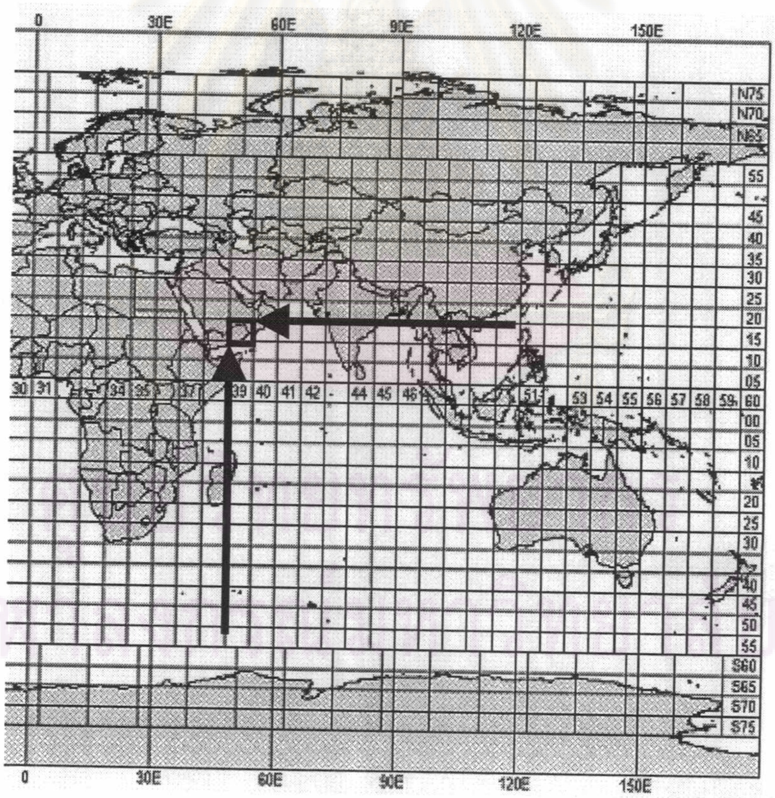


Figure- 2.1.Map showing the numbering system for UTM zones, the zones extend from 80 degrees south to 84 degrees north latitudes.

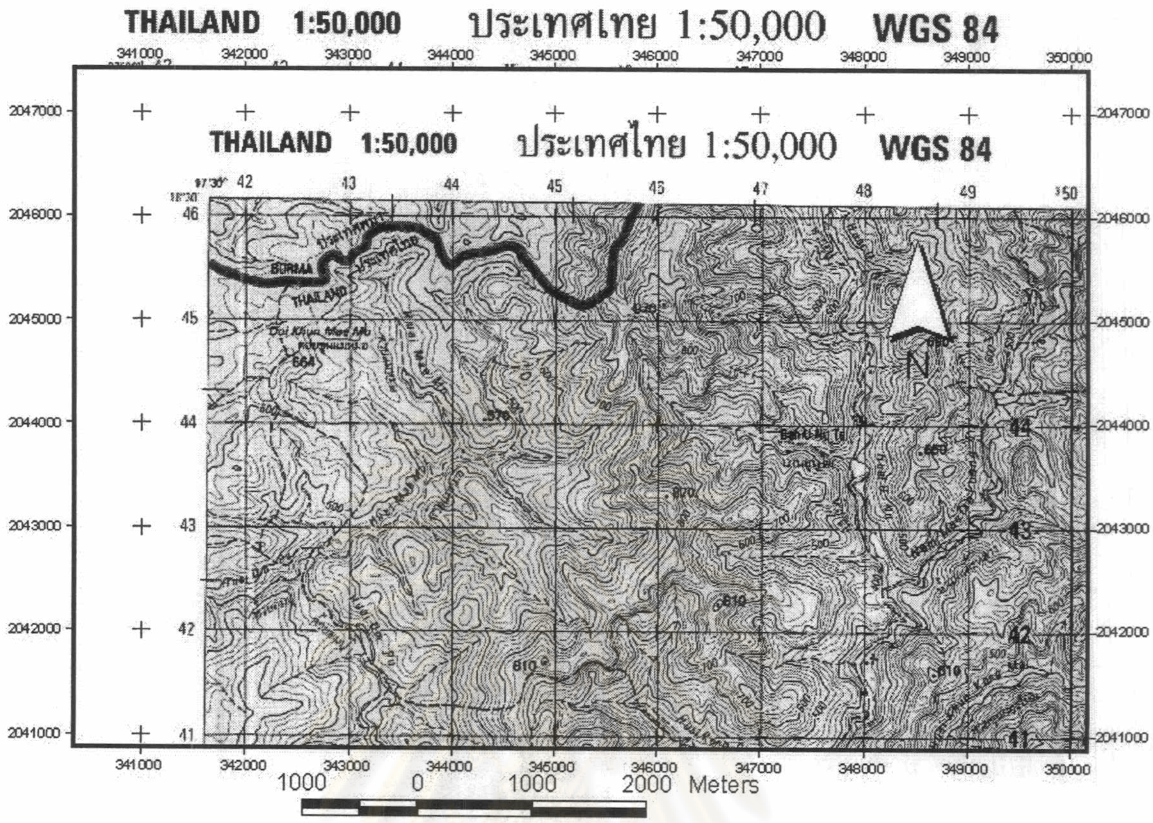


Figure- 2.2. UTM grid on a 7.5 minute topographic map showing UTM coordinates.

Spheroid ……… Everest
Grid ……….1,000 Meter UTM, Zone 47
Projection . ...Transverse Mercator
Vertical Datum........Mean Sea Level At Ko Lak
Horizontal Datum….INDIAN Datum
Control By………….RTSD

The UTM coordinates (measures of distance) are arranged so they always read from left- to-right and from bottom-to-top (see Figure-2.2). The smallest value is 160 km and it is at the equator. As one moves away from the equator, the UTM east coordinate at the zone's western edge has larger and larger values. At 84 degrees north latitude it is 465 km. Likewise, the eastern (right) zone boundaries will have coordinates of 834 km at the equator and 515 km at 84 degrees north latitude. By the way the square grid is placed on each zone is shown in Figure 2.2. Refer to this Figure, Taking at the UTM grid, which is a familiar 7 .5 minute quad with emphasized UTM grid lines 1000 meters (1kilometer) apart.

2.2. Datum and Ellipsoids

The World Geodetic System (WGS) is not referenced to a single datum point. represents an ellipsoid whose placement, orientation, and dimensions best fit the Earth's equipotential surface which coincides with the geoid. The system was developed from a worldwide distribution of terrestrial gravity measurements and geodetic satellite observations.

Datum conversions are accomplished by various methods. Complete datum conversion is based on seven parameter transformations that include three translation parameters, three rotation parameters and a scale parameter. Simple three parameter conversion between latitude, longitude, and height in different datums can be accomplished by conversion through Earth-Centered, Earth Fixed XYZ Cartesian coordinates in one reference datum and three origin offsets that approximate differences in rotation, translation and scale (see Table -2.2 (a) ,(b), and (c)).

Ellipsoidal Earth models are required for accurate range and bearing calculations over long distances. GPS navigation receivers use ellipsoidal Earth models to compute position and waypoint information. Ellipsoidal models define an ellipsoid with an equatorial radius and a polar radius. The best of these models can represent the shape of the Earth over the smoothed, averaged sea-surface to within about one hundred meters.

Coordinate Operation Method Name	**Areas used**	**Central meridian**	**Latitude of natural origin**	**CM Scale Factor**	**Zone width**	**False Easting**	**False Northing**
Transverse Mercator	Various, world wide	Various	Various	Various	Usually less than 6°	Various	Various
UTM North hemisphere	World wide equator to 84° N	6° intervals E & W of 3° E & W	Always 0°	Always 0.9996	Always 6°	500000m	0m
UTM South hemisphere	World wide north of 80° S to equator	6° intervals E & W of 3° E & W	Always 0°	Always 0.9996	Always 6°	500000m	10000000m

Table-2.2(a). Transverse Mercator projection and UTM projection

	WGS 84	INDIAN 1975 Everest (1830)	INDIAN 1954 Everest (1830)
Semi-major Axis(a)	6,378,137	6,377,276.345	6377301.243
Semi-minor Axis(b)	6,356,752.3142	6,356,075.4133	6,356,075.4133
Flattening (f)	1/298.25722 3563	1/300.8017	1/300.8017
Δx	0	206 (+/-3)	217 (+/-15)
Δy	0	837 (+/-2)	823 (+/ -6)
Δz	0	295 (+/-3)	299 (+/-12)

Table-2.2 (b).Geodetic Datum Transformation Parameters

Datum	**Ellipsoid**	**ΔX**	**ΔY**	**ΔZ**	**Region of use**
Indian 1954	Everest (India 1830)	217	823	299	Thailand
Indian 1975	Everest (India 1830)	206	837	295	Thailand

Table-2.2 (c).Geodetic Datum Transformation Parameters (Local to WGS-84)

2.3. Change of Datum

(i). To change from one system to another via a datum change is a lengthy process.

Using the ellipsoid, projection and grid parameters for system :

a. Convert the grid eastings, northings and height to geodetic latitude, longitude and height.
b. Convert the geodetic latitude, longitude and height to Cartesian (X,Y,Z) values in meters.
c. Convert the new Cartesian X,Y,Z values to geographic latitude, longitude and height.
d. Convert the geographic latitude, longitude and height to grid eastings, northings and height.

(ii). The parameters that define the differences between 2 datums are as follows:

a. The differences in meters between the two ellipsoid centers called Δx, Δy, Δz .
b. The rotation about the Z axis is seconds of arc between the two ellipsoids 0° longitude

c. The difference in size between the two ellipsoids

d. The rotations in seconds of arc about the X and Y axis, the attitude of the spin axis.

(iii). Ellipsoids are generally defined with their rotation axis Z parallel to the spin axis of the earth; therefore, rotations about the X and Y axis will be zero, negating two of the parameters. On the other hand, there will be small differences between the ellipsoid sizes; therefore, 5 parameter shifts are common. However, the main difference is the position of the centers of the ellipsoids, so the common practice uses only ΔX, ΔY, ΔZ. There mainly use a 3 parameter shift for its transformation (see Table-2.2(b) and (c)).

(iv). Transformation parameters are computed from the coordinates of stations that are common to both systems. Their accuracy depends upon the quality of the coordinates in both systems.

(v). WGS 84 with GPS has provided a quick and simple method to transform between datums. If known stations of any country have been surveyed in WGS 84 then the transformation parameters to a national system may be computed. WGS 84 provides a common pivot that enables a datum change between most systems.

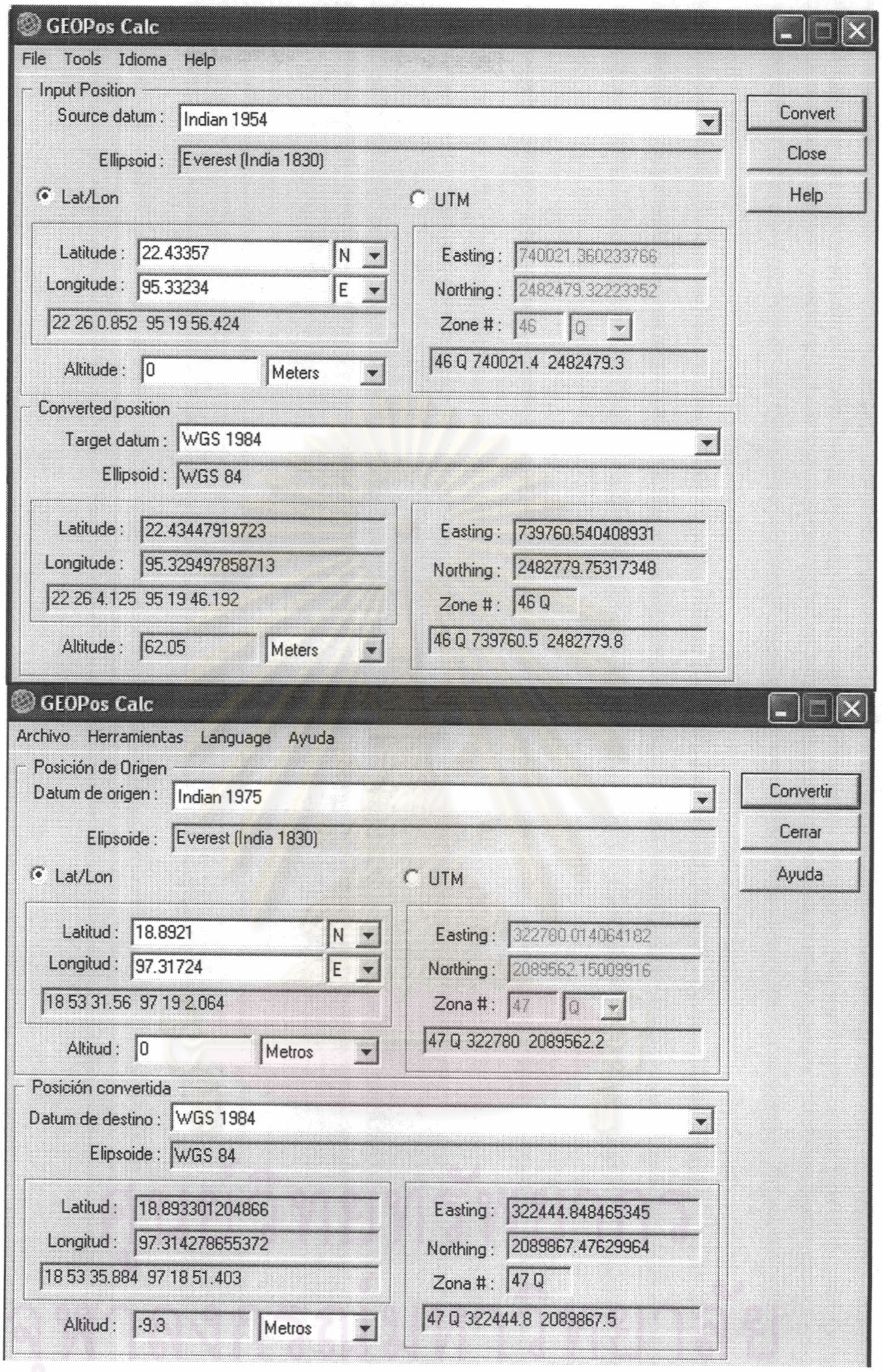


Figure-2.3. Estimates for WGS-84 and Everest1830 (Indian-1975) Transformation using byGEOPos Calc.

2.4.Error Estimates for WGS-84 and Everest1830 (Indian-1975) Transformation

(a) Actual GPS observations were made to get the precisely measured coordinates of those points in WGS-84 system and a comparison was made to determine the extent of error between these two observations.

(b). Direct comparison of the values of WGS-84 and Everest Coordinates of various points without conversion was also done to determine the maximum extent of error between these two systems of coordinates.

(c). These observations (and comparison) were done for Latitudes and Longitudes only.

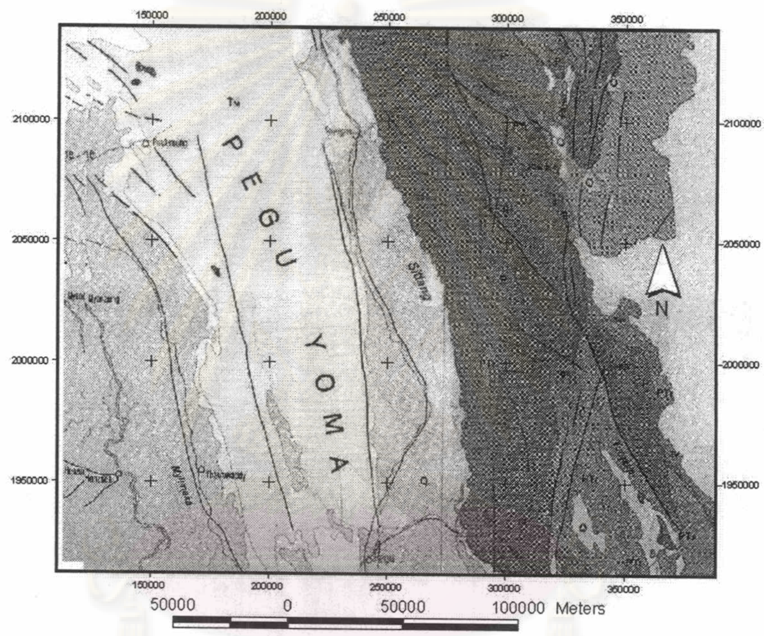


Figure-2.4. Original map showing the Geology of Burma .

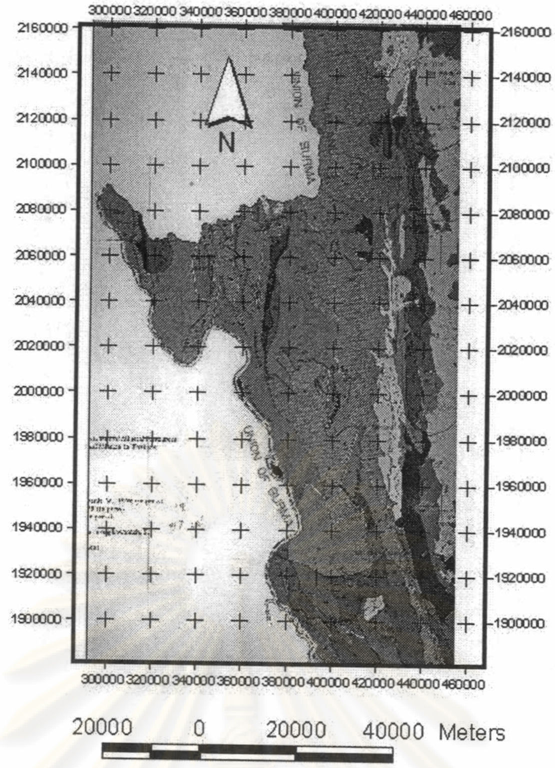


Figure-2.5. Original map showing the Thailand geological map .

2.5. Map Scale

The next problem be using different scale map such as geological map of Thailand (1:500,000 scale) and Geology of Burma (1:2000,000 scale). When departing from standard sheet lines to avoid unnecessary sheets or because of datum changes, corners are labeled to 1 second for 1:250,000 and 1:100,000 scale and to 0.1 second for 1:50,000 to 1:12,500 scale. The interval is selected in accordance with the map scale. The unit intervals shown on map scales are in Table-2.3.

MAP SCALES	UNIT INTERVALS
1:25,000	1,000
1:50,000	1,000
1:500,000	10,000
1:1,000,000	10,000

Table-2.3.Grid Unit Intervals for Various Scale

In topographic mapping, horizontal accuracy will be within 0.5mm of their true position (when plotted to scale). So for example 0.5mm at 1:50,000 scale is 0.5x50,000 = 25 meters. Depending on the scale of the map, the actual ground distance represented by 1/30th and 1/50th of an inch will vary. To determine the minimum standards for horizontal accuracy in actual ground meters, the following calculation must be performed.

- If larger than 1:20,000-scale, use this calculation:

0.03333 x scale x 2.54 / 100 = ground meters.

- If 1:20,000-scale or smaller, use this calculation:

0.02 x scale x 2.54 / 100 = ground meters.

Result of study area:

_For 1:50,000-scale maps:

0.02 x 50,000 x 2.54 / 100 = 25.4 meters (or 84.58 ft)

_ For 1:250,000-scale maps:

0.02 x 250,000 x 2.54 / 100 = 127 meters (or 422.91 ft)

_For 1:500,000-scale maps:

0.02 x 500,000 x 2.54 / 100 = 254 meters (or 845.82 ft)

Map Scale	Ground Meters
1:50,000	25.4
1:250,000	127
1:500,000	254

Table-2.4. Conversion table for each scale of Topographic map

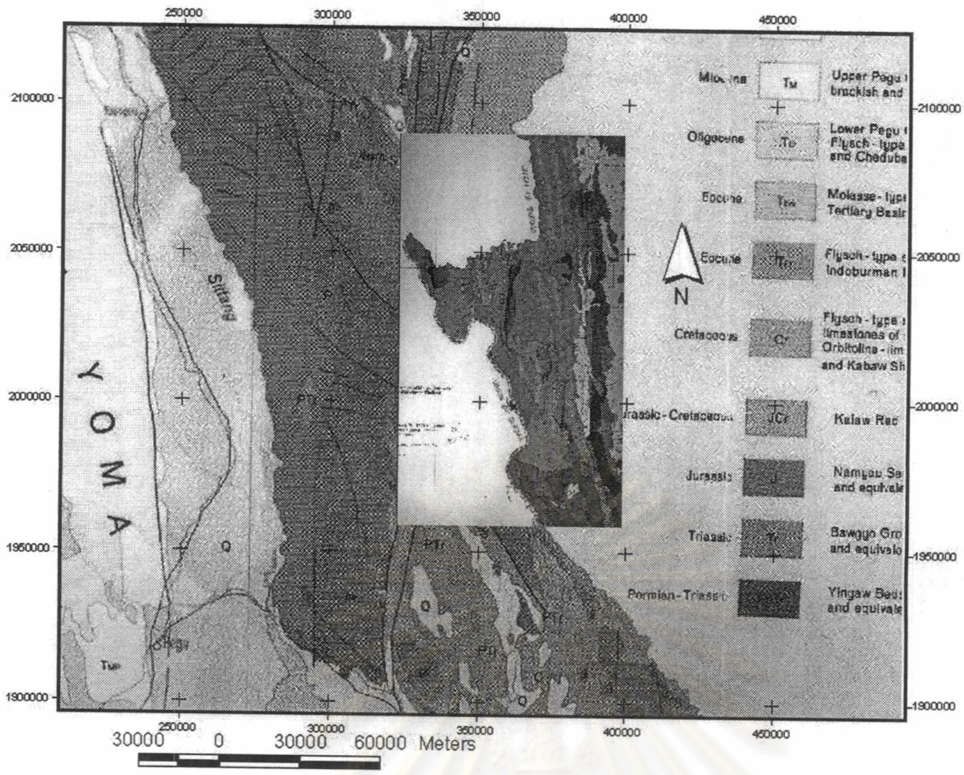
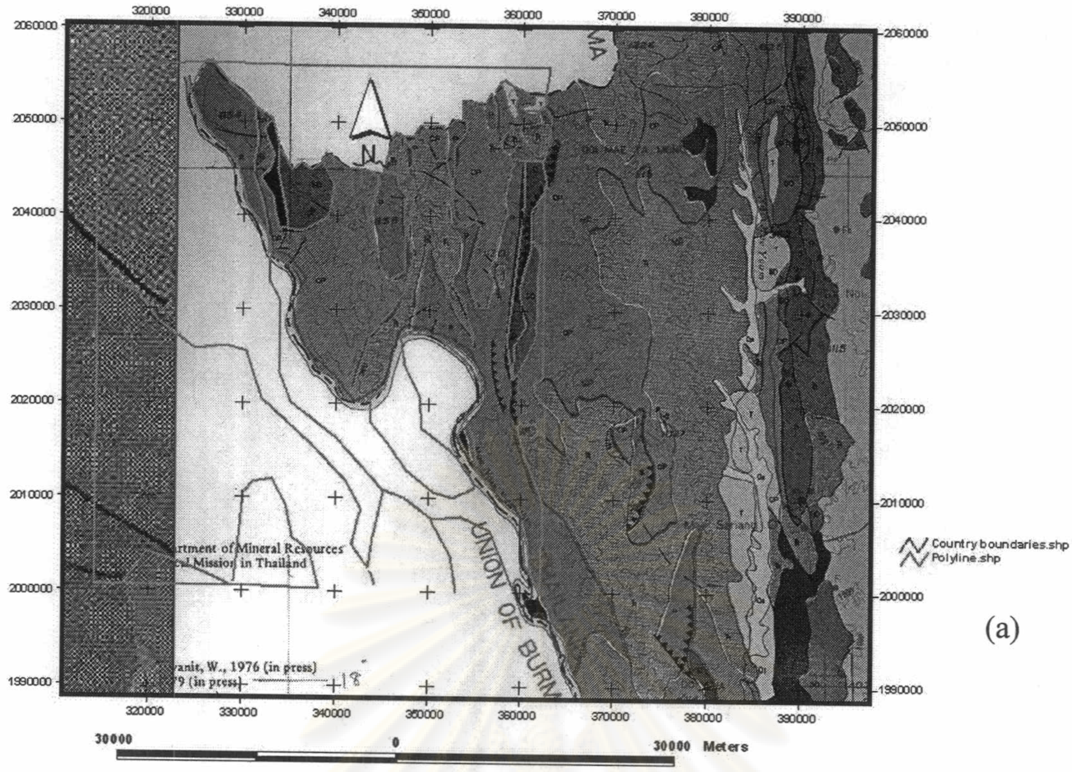
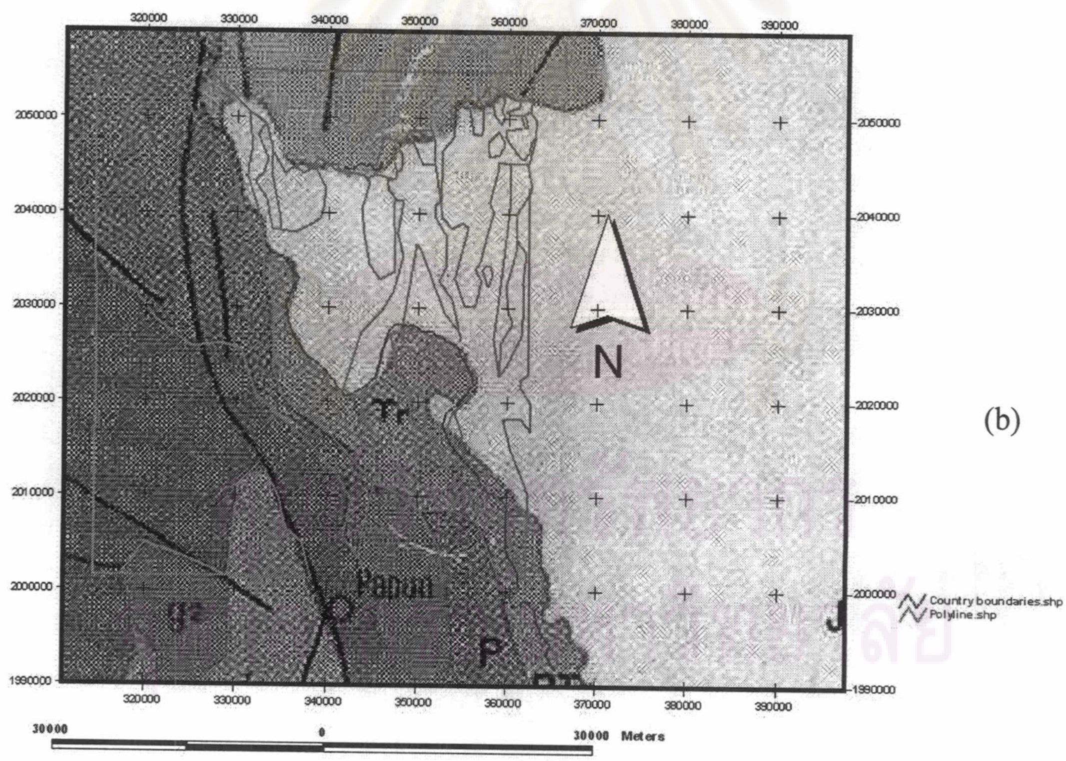


Figure-2.6. Original map showing the overlapping of Thailand geological map and Geology of Burma .

Figure-2.6 shows how the effectiveness of geo-referencing and boundary fitting can be overlaied using adjustment techniques. A data maintaining strategy is presented which regards point coordinates just as a view on redundant primary data. Height accuracy is usually one third of the contour interval according to international standard. Most of pixel size of the scanned raster data will be 200 ~ 400 d.p.i. (dot per inch) or 0.1 mm interval on maps. Generally, a line cannot be drawn much narrower than about 1/2 a millimeter. Therefore, on a 1:50,000 scale paper map, the minimum distance which can be represented (resolution) is about 25 metres.



(a)



(b)

Figure-2.7.Map showing the error of political boundary (a) geological map of Thailand and (b) geological map of Burma.