250 Glorious Years of the Service to the Nation

History of Everest Height Measurement by Survey of India

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CELEBRATING **250 YEARS** OF SURVEY OF INDIA

VISION ///
Survey of India takes a leadership role in providing customer focused, cost effective and timely geospatial data, information and intelligence for meeting the needs of security, sustainable national development and new information markets

MISSION /// Survey of India dedicates itself to the advancement of theory, practice, collection and applications of geospatial data, and promotes an active exchange of information, ideas, and technological innovations amongst the data producers and users who will get access to such data of highest possible resolution at an affordable cost in the near real-time environment.

- **Survey of India was the first agency to determine the height of Mount Everest** as 29002 ft, in 1850 and identify it as the world's highest peak.
- Subsequent observations of 1952-54 by Survey of India yielded the height of the Mt. Everest as 8848 m which is the accepted figure till date.
- Many other countries have also attempted to determine height of the Mount Everest using conventional as well as modern techniques. Its precise height has long been a matter of interest and debate among surveyors and geographers all over the world.

I

First Measurement
1849 - 1855

I Background

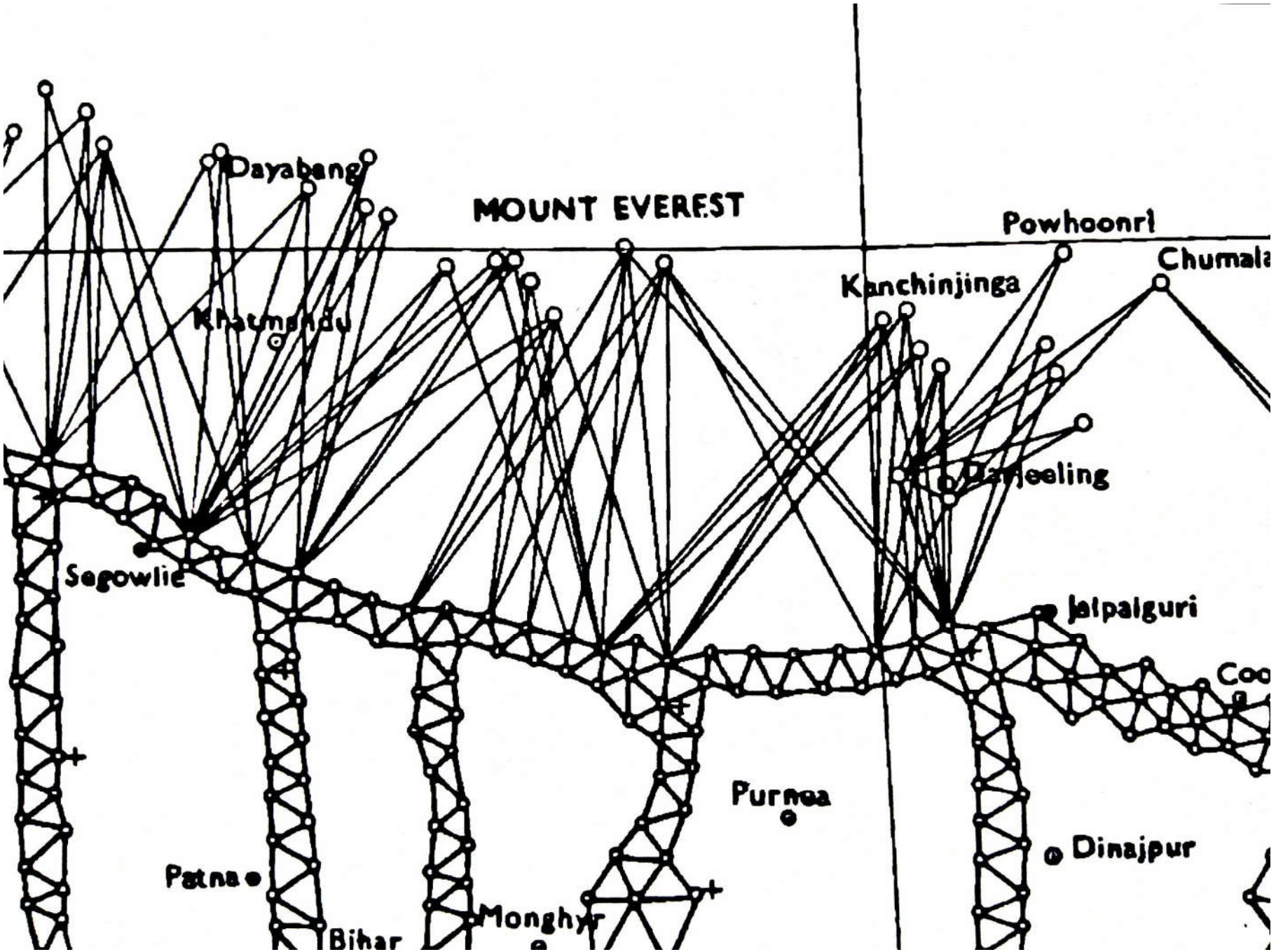
- During 1849–1855, observations were made for North-East Longitudinal Series from Dehradun base to Sonakhoda base in Bihar.

- During these triangulation observations, the Himalayan peaks of Nepal were also observed.

- At that time it was not known that this peak in Himalayas is the highest in the world. Though the Himalayas were speculated by many as the highest mountains.

- During computations the mean computed height of ‘Peak XV’ came out to be 29002 ft and it was named after Sir George Everest, the Ex Surveyor General of India.


BAY OF BENGAL
CEYLON
INDEX CHART
TO THE
GREAT TRIGONOMETRICAL SURVEY
OF
INDIA


MOUNT EVEREST
Dayabang
Powhoonri
Kanchinjinga
Segowlie
Jalpaiguri
Purnea
Patna
Dinajpur
Bihar
Monghyr

I

Important Factors : Visibility

- The observation stations were in the plains of Bihar, more than 150 km away from Mount Everest. These stations were at an average height of about 230 ft above MSL.
- Towers of 25 - 30 ft were used to make the stations inter-visible.
- The observers were instructed to be in the observatory before sunrise so that the observations may be made a soon as it is light. It was extremely difficult to get visibility over such long distances in the afternoon.
- Vertical angles were taken from 8 to 10 A.M.

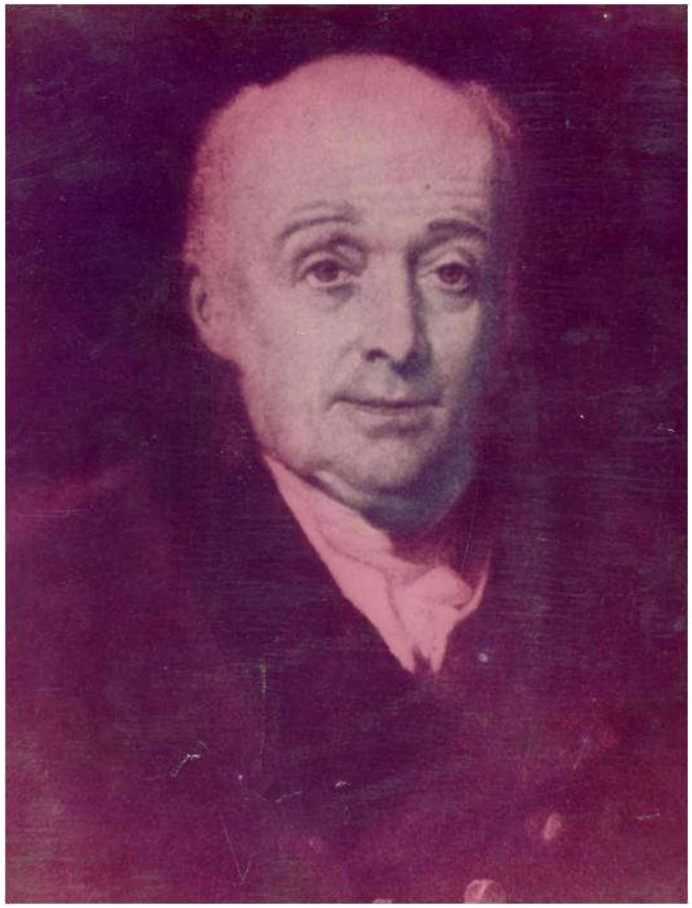
I

Important Factors : Refraction

- In the earliest days also it was realized that refraction is an important factor when observing high mountain peaks from long distances.

- Sir Andrew Waugh took elaborate observations for determining the curvature of the path of the rays between a number of peaks in outer Himalayas and plains of Bengal by simultaneous reciprocal observations.

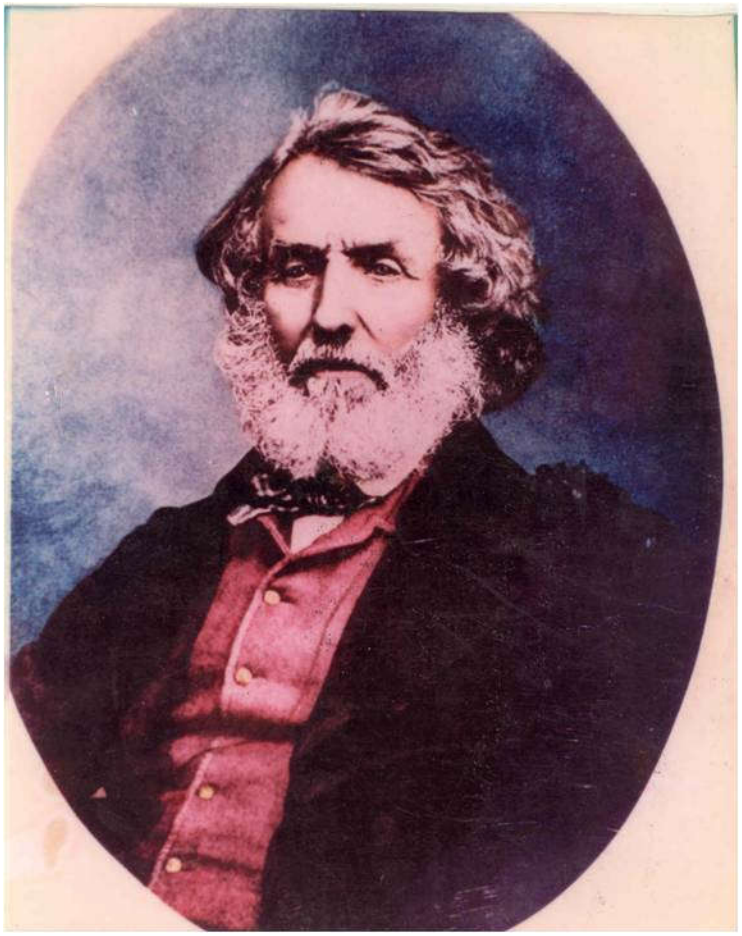
- The value of Coefficient of Refraction was taken as 0.07 to 0.08.



COL. WILLIAM LAMBTON

SUPERINTENDENT OF GTS

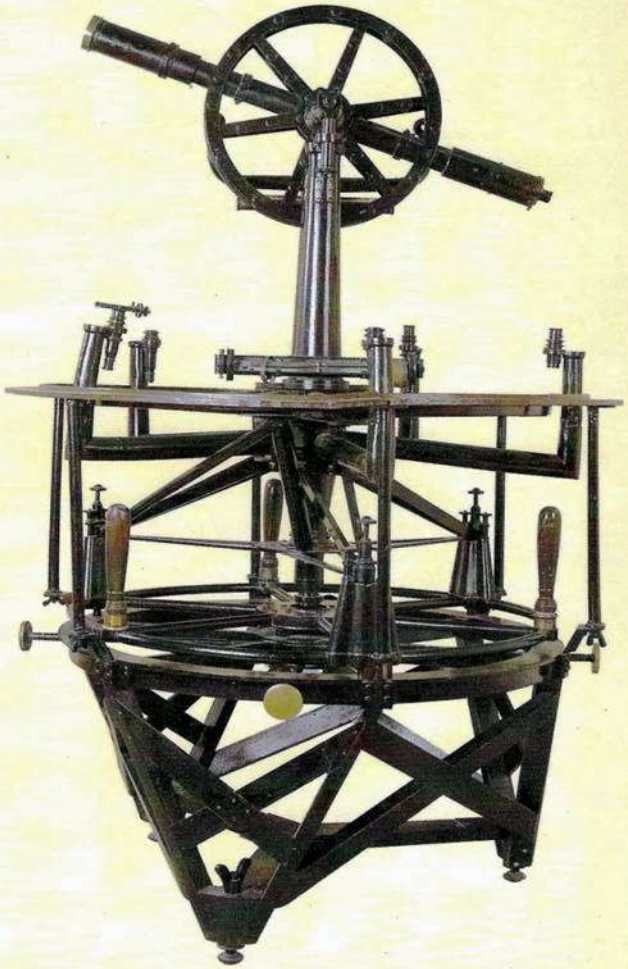
FROM 1818 – 1823



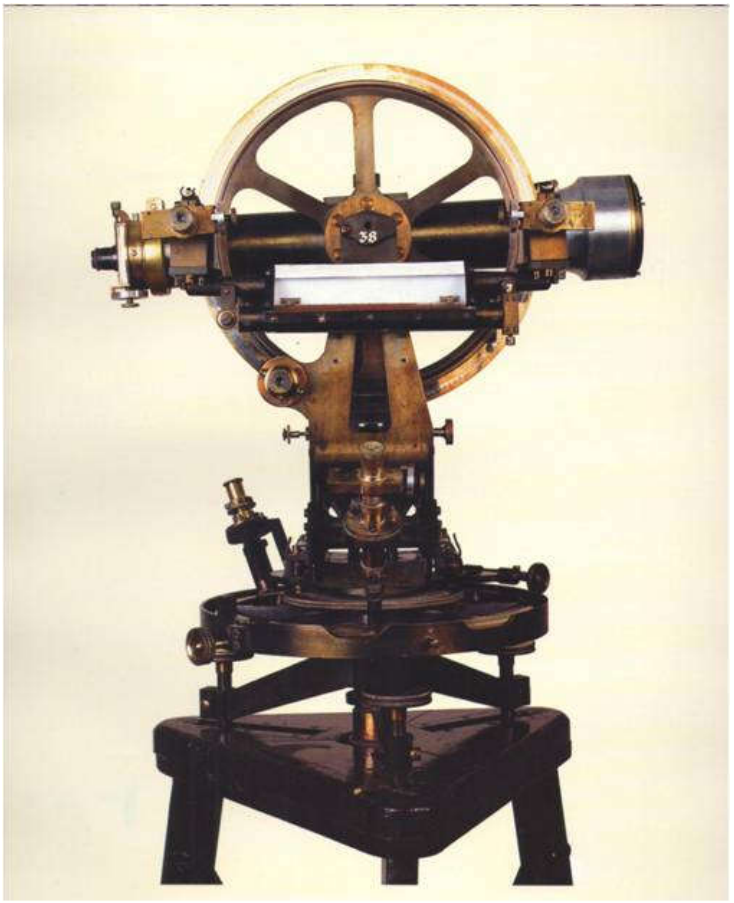
SIR GEORGE EVEREST

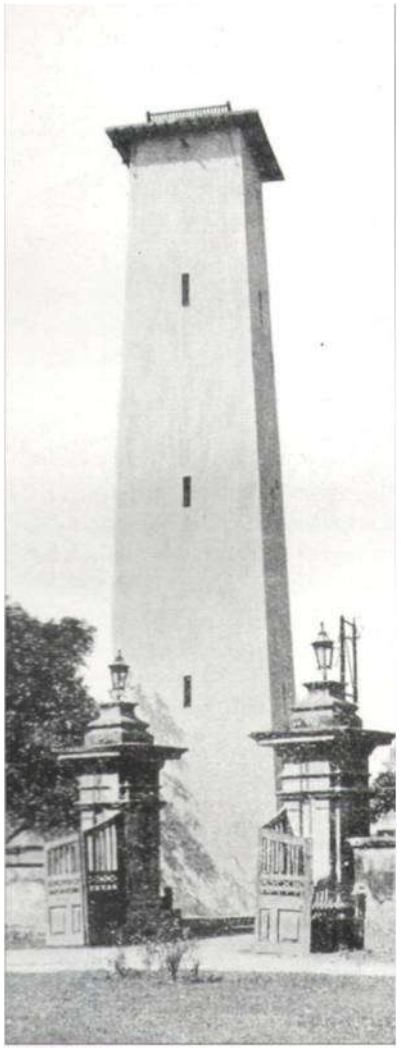
SURVEYOR GENERAL OF INDIA

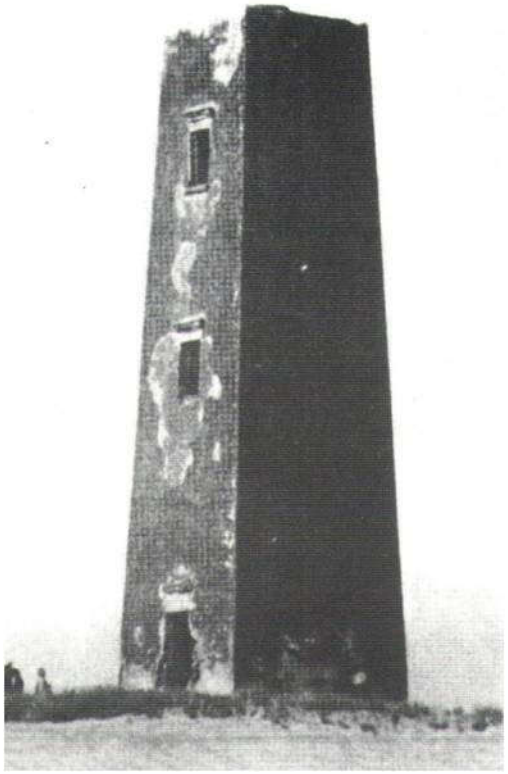
From 1830-1843



Specially commissioned by Lambton from Cary of England, the Great Theodolite weighed half a ton. It was fitted with a 36-inch horizontal circle, 18-inch vertical circle and 5 verniers. The readings were so fine they had to be read through microscope fitted on each circle.





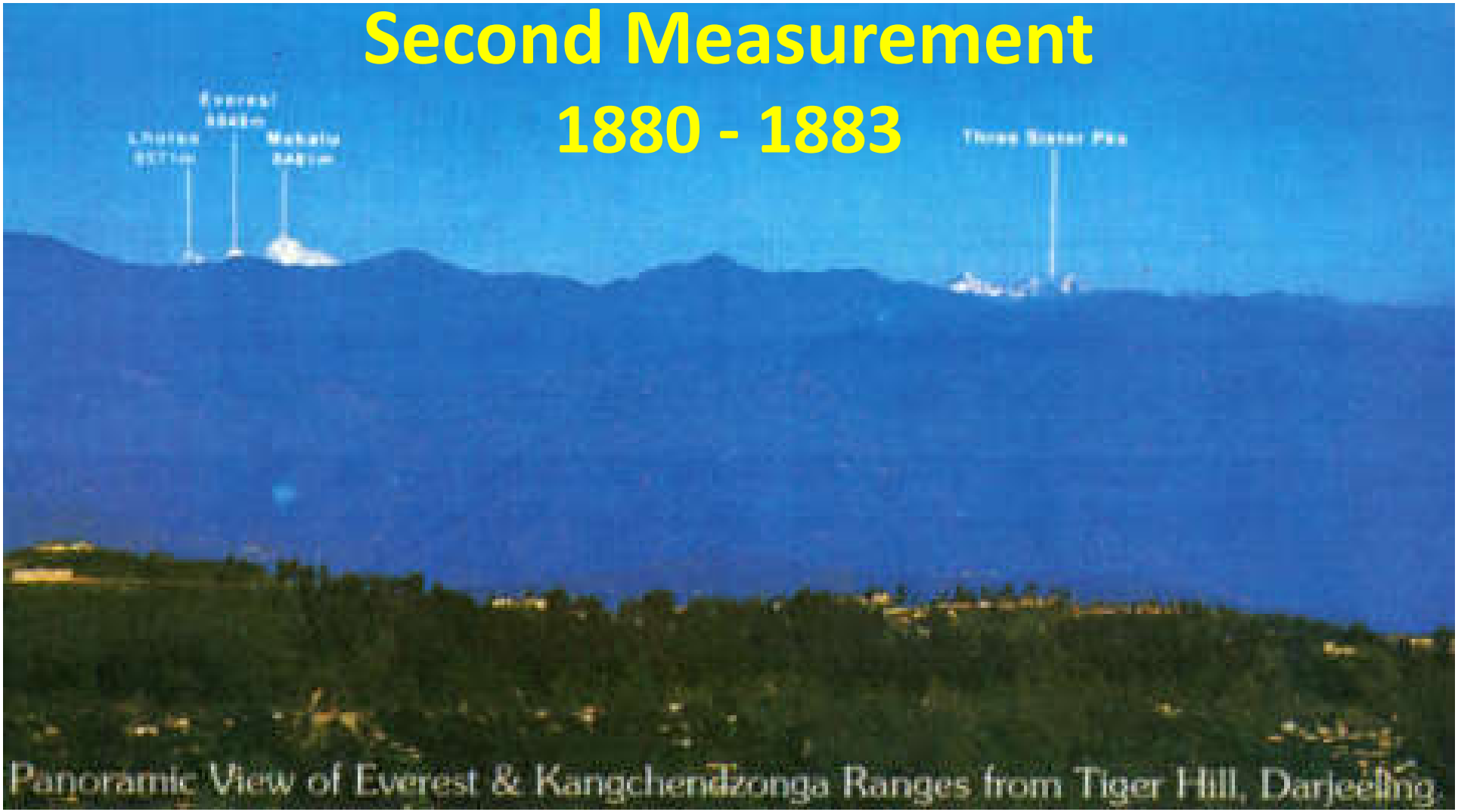


Comments

- Erroneous value of coefficient of refraction (Too high)
- No consideration of deflection of vertical
- Undefined Datum

II

Second Measurement
1880 - 1883

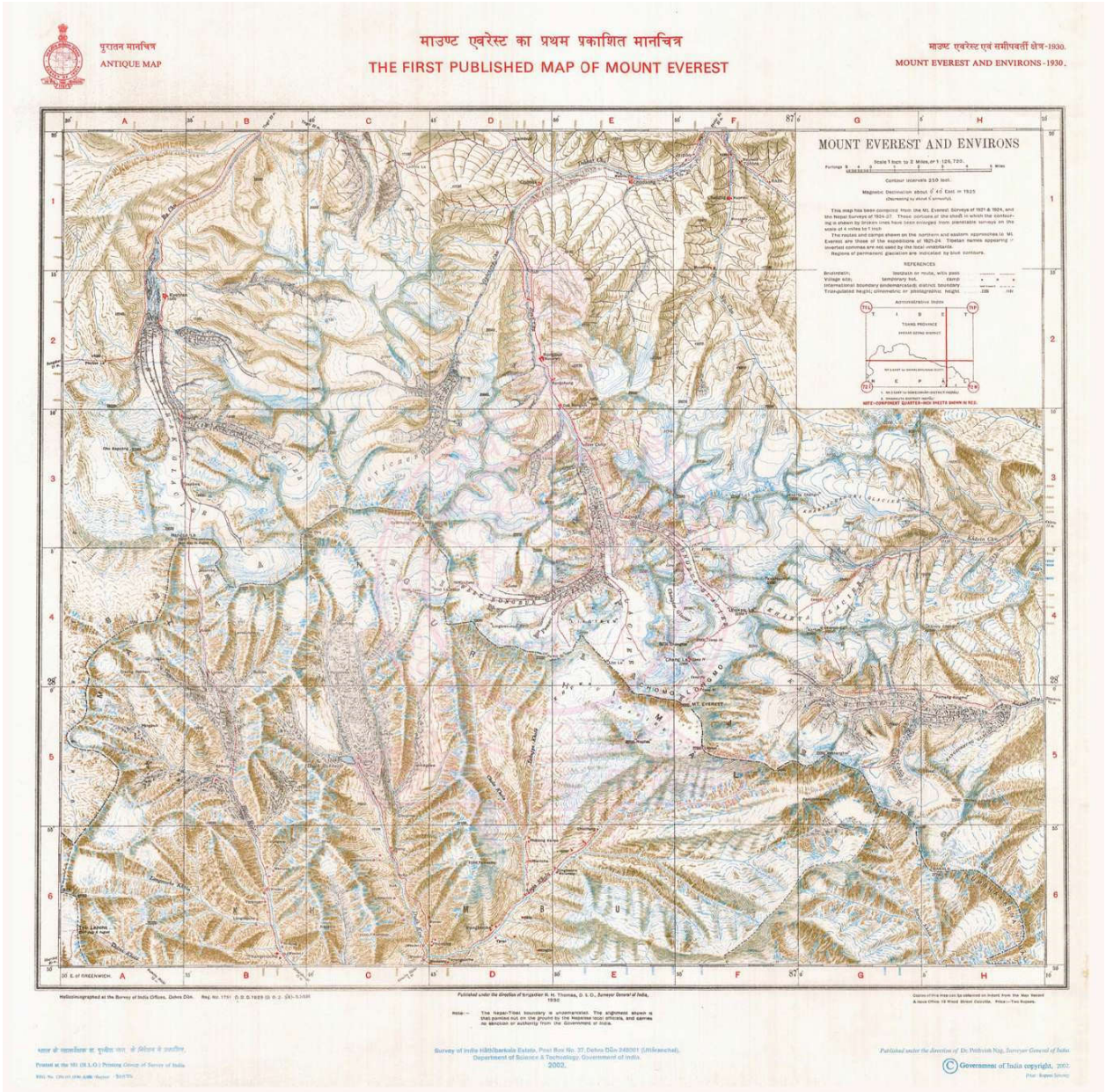


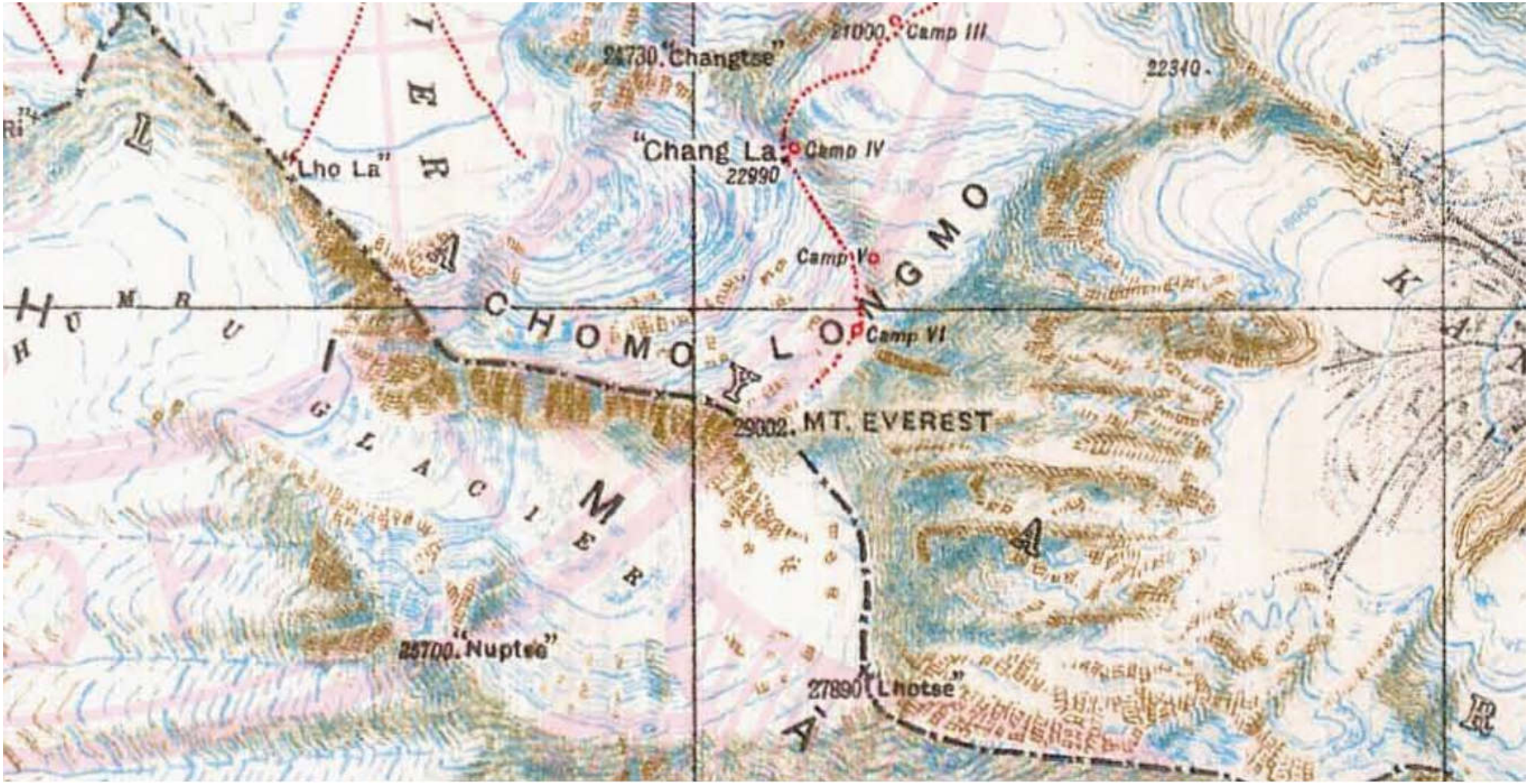
Panoramic View of Everest & KangchenDzonga Ranges from Tiger Hill, Darjeeling

II

- In 1880-83 and 1902, observations were taken from Darjeeling hills as part of normal survey program.
- These observation stations had the advantage of being at higher level.
- The coefficient of Refraction taken by Col SG Burrard was 0.05.
- The value of height obtained by Burrard was 29,141 ft.
- This height was also above undefined datum.
- The deflection of plumb line was not taken into account.

First Map of Mount Everest 1930
(Reprint under Antique Map Series)




24730. "Changtse"
21000. Camp III
22340
"Lho La"
"Chang La"
Camp IV
22990
Camp V
Camp VI
29002. MT. EVEREST
25700. "Nuptse"
27890. "Lhotse"
HUMBU GLACIER
CHOMOLONGMO

III

Third Measurement
1952 - 1954

III

Background

- This work was undertaken during 1952 to 1954 especially to determine the height of Mount Everest.
- Careful planning was done keeping in view the difficult terrain and lack of transport.
- Mount Everest was observed from 8 stations.
- The value obtained was 29,028 ft or 8848 m which is accepted till date.
- This exercise was carried out taking into account various factors like deflection of vertical and refraction.

III

Heights of Observing Stations

- The heights of observing stations used in older exercises of 1850s and 1880s were erroneous as the concept of reference spheroid and plumb line deflection were vague.
- Later, when this concept developed, the heights were corrected. Most of the values changes by about 8 feet on an average.
- The heights of higher stations used in 1880s changed by more than 15 ft.
- In exercise of 1952-54, special care was taken to provide adequate number of spirit-levelled connections in the new triangulations.

Example : Change in Heights of Observation Stations

Station of Observation	Height Used in Old Computation (ft)	Heights after Adjustment (ft)	Difference (ft)
Jarol T.S.	231	220	-11
Mirzapur T.S.	254	245	-9
Janjipati T.S.	263	255	-8
Ladnia T.S.	242	235	-7
Harpur T.S.	226	219	-7
Minai T.S.	237	228	-9

III

Refraction

- The following formula was used for Coefficient of Refraction

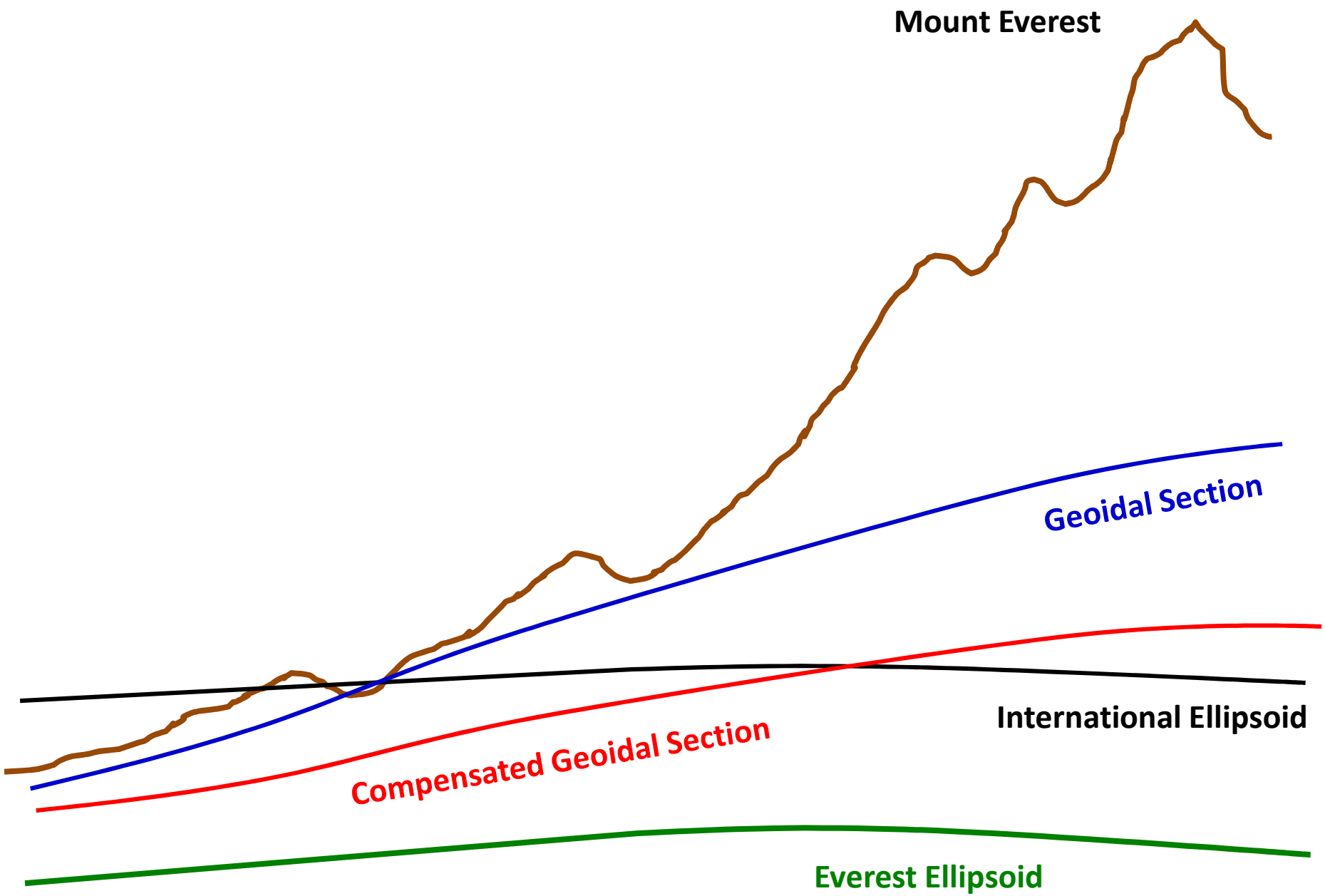
$$k = 50{,}000 \frac{P}{T^2}(0.0187 + \beta)$$

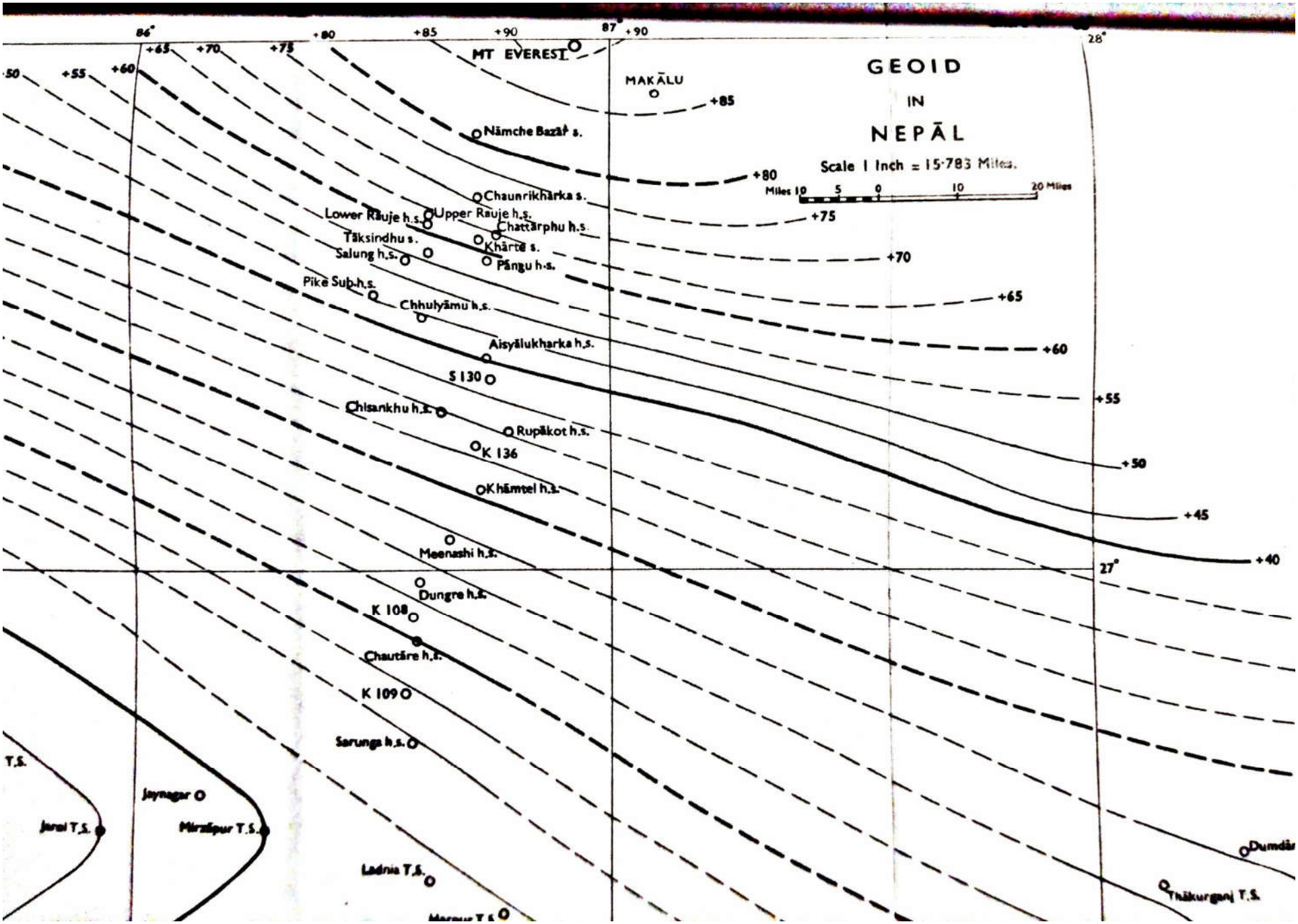
- Where T is temperature in absolute degree F,
- B is temperature gradient of atmospheric layers in degree F/ft taken as 3.2°F/1000 ft
- P is Pressure

III

Datum

- The old measurements were over some undefined datum.
- During the measurement of 1952-54, efforts were made to determine the geoidal rise around Mount Everest
- Observations were made for deflection of vertical which was further used to compute geoidal undulation.
- International Ellipsoid was used in computations because it had considerable improvements as compared to Everest Ellipsoid.


Mount Everest
Geoidal Section
International Ellipsoid
Compensated Geoidal Section
Everest Ellipsoid


GEOID
IN
NEPĀL
Scale 1 Inch = 15·783 Miles.
Miles 10 5 0 10 20 Miles
MT EVEREST
MAKĀLU
+85
Nāmche Bazār s.
+80
Chaunrikhārka s.
Lower Rāuje h.s.
Upper Rauje h.s.
Chattārphu h.s.
Tāksindhu s.
Khārtē s.
Salung h.s.
Pāngu h.s.
+75
+70
Pike Sub-h.s.
Chhulyāmu h.s.
+65
Aisyālukharka h.s.
+60
S 130
+55
Chisankhu h.s.
Rupākot h.s.
+50
K 136
Khāmtel h.s.
+45
Meenashi h.s.
+40
Dungre h.s.
K 108
Chautāre h.s.
K 109
Sarunga h.s.
Jaynagar
Jaynagar T.S.
Mirzāpur T.S.
Ladnia T.S.
Thākurganj T.S.
86°
87°
28°
27°

III Positions of Stations and Mt. Everest

- Earlier, Mount Everest was observed from the stations which were not intervisible. Thus the position of Mount Everest was doubtfully fixed.
- During 1952-53, the triangulation network was extended to various hills comparatively nearer to Mount Everest.
- The coordinates of Mount Everest were recalculated and were shifted by about 40 ft towards south-west.

III

- Mount Everest was observed from following 8 stations:
  - Mayam
  - Laori Danda
  - Aisyalukharka
  - Chhulyamu
  - Pike Sub.
  - Sollung
  - Lower Rauje
  - Upper Rauje

TABLE 5.—*Height of Mount Everest*

Station (1)	Season (2)	Distance (3)	Height of station (4)	Spheroidal height difference (5)	Sum (6)	δN = Geoidal rise between the station and Mount Everest (7)	Geoidal height of Mount Everest = (6)−(7) (8)
		miles	feet	feet	feet	feet	feet
Mayām ..	1952–53	47	10948·1	18145·6	29093·7	55	29038·7
Lāori Danda ..	1952–53	42	11877·4	17206·2	29083·6	51	32·6
Aisyālukharka ..	1952–53	42	8670·3	20412·7	29083·0	52	31·0
Chhulyāmu ..	1952–53	41	10160·4	18920·1	29080·5	50	30·5
Pike Sub. ..	1952–53	41	12059·3	17011·8	29071·1	47	24·1
Sollung ..	1952–53	36	11657·9	17411·4	29069·3	40	29·3
Lower Rauje ..	1952–53	30	13357·4	15700·8	29058·2	32	26·2
Upper Rauje ..	1952–53	29	14762·1	14293·1	29055·2	30	25·2
Sollung ..	1953–54	36	11657·9	17409·9	29067·8	40	27·8
Pike Sub. ..	1953–54	41	12059·3	17015·3	29074·6	47	27·6
Upper Rauje ..	1953–54	29	14762·1	14290·7	29052·8	30	22·8
Chhulyāmu ..	1953–54	41	10160·4	18917·8	29078·2	50	29028·2

Present (Proposed) Exercise

Considerations Required:

- Which Vertical Datum will be used ?
- If Geoid : Hybrid Geoid ?
- Height of Rock OR Height of Snow Peak ?
- How to find height of rock/depth of snow (if it is the objective)
- Duration of GNSS observation at the peak considering limited stay time available. (any alternate method to increase observation time)
- GNSS Data Processing
- Check for stability of BMs ?

Conclusion

- The proposed project for Measurement of the Height of Mount Everest is a Welcome step.
- The exercise will not only provide new computed height but will also provide information which will be useful in understanding the result of plate movement, if such exercise are repeated in future also.
- The exercise will provide opportunity for knowledge sharing.


Thanks for Your Attention
All The Best