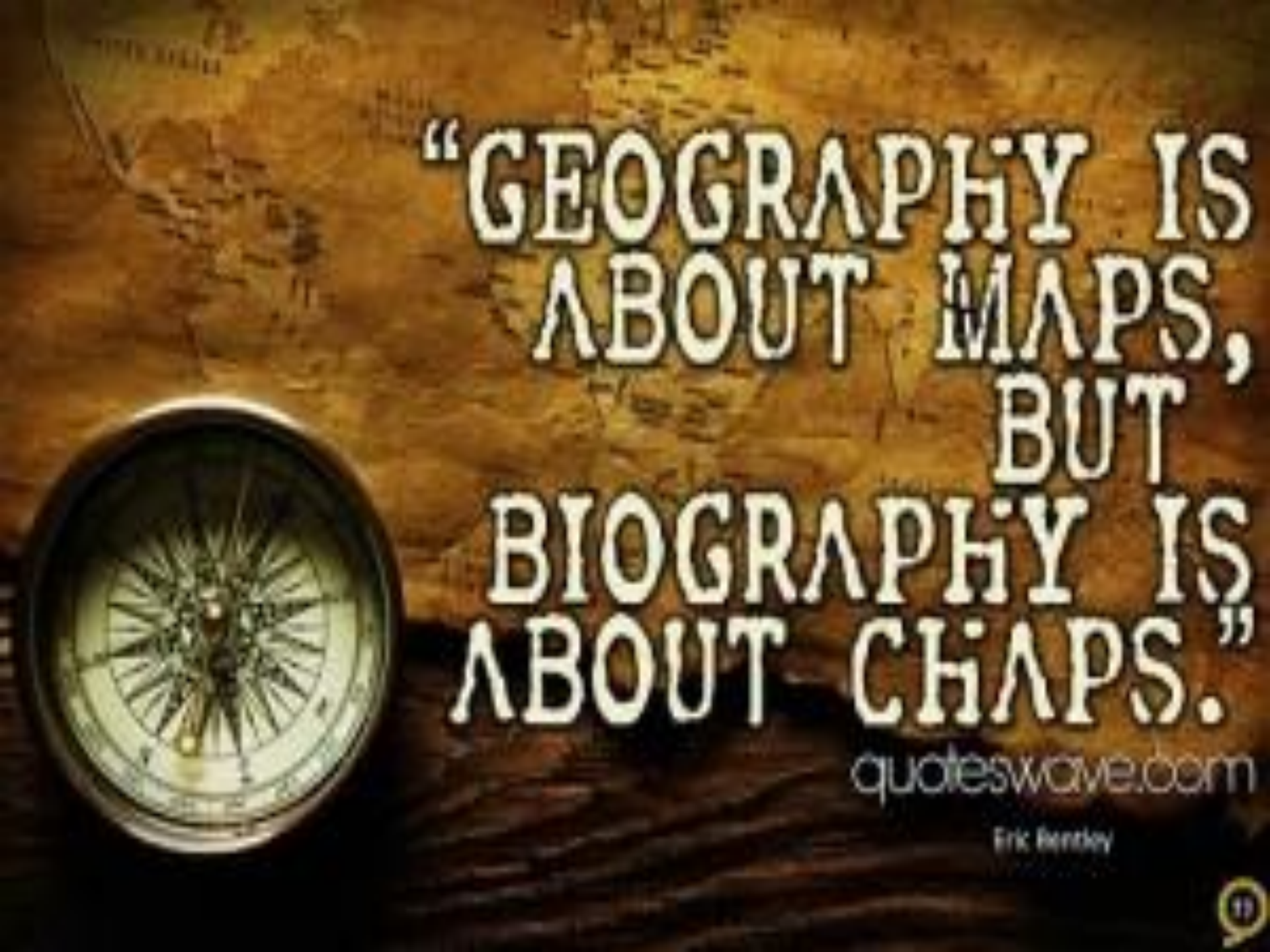
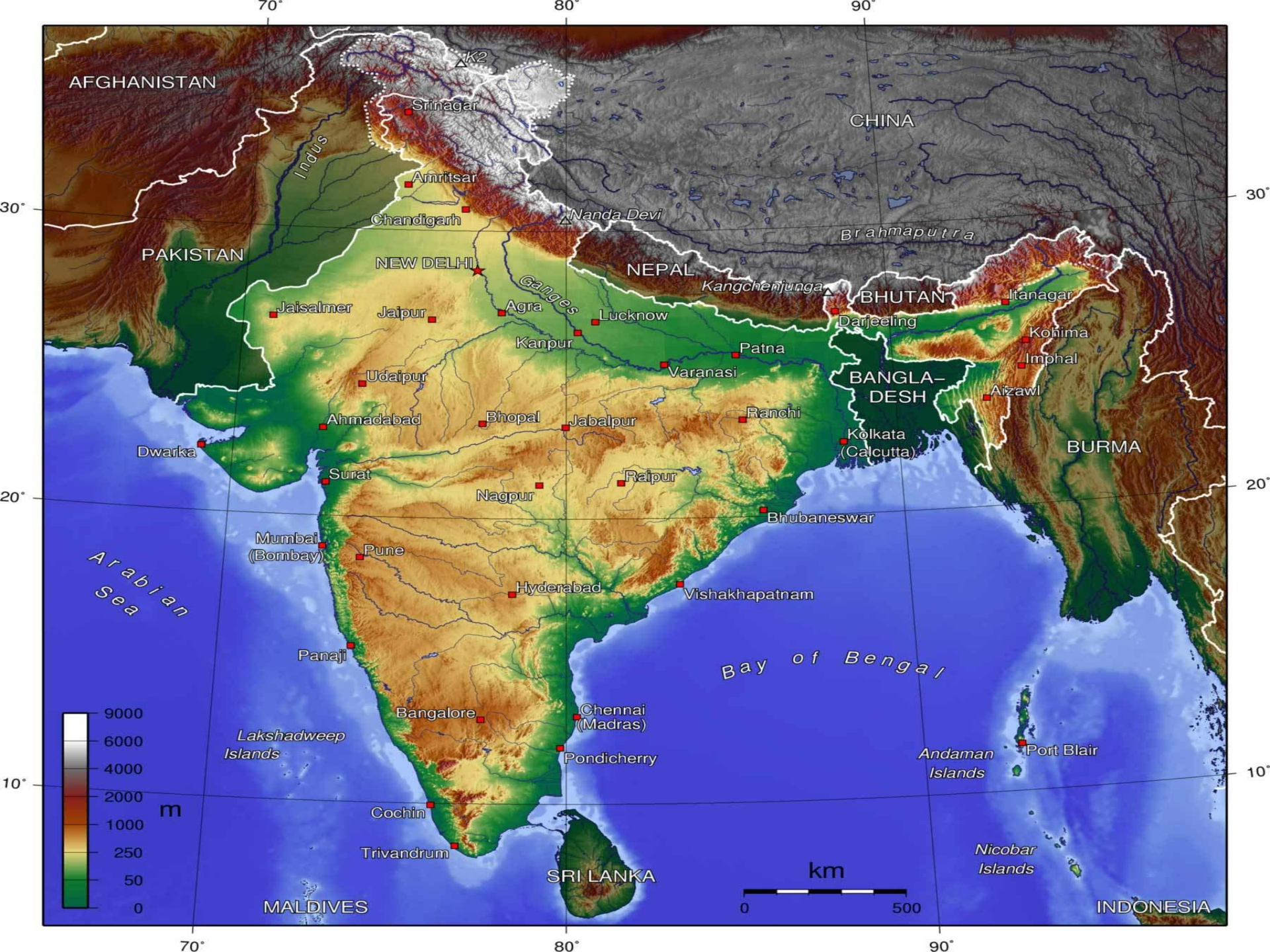

MAPPING AN EMPIRE


"GEOGRAPHY IS
ABOUT MAPS,
BUT
BIOGRAPHY IS
ABOUT CHAPS."
quoteswave.com
Eric Bentley


AFGHANISTAN
PAKISTAN
CHINA
NEPAL
BHUTAN
BANGLA-
DESH
BURMA
SRI LANKA
MALDIVES
INDONESIA
K2
Srinagar
Amritsar
Chandigarh
Nanda Devi
NEW DELHI
Kangchenjunga
Brahmaputra
Indus
Ganges
Jaisalmer
Jaipur
Agra
Lucknow
Kanpur
Patna
Varanasi
Udaipur
Ahmadabad
Bhopal
Jabalpur
Ranchi
Dwarka
Surat
Nagpur
Raipur
Kolkata
(Calcutta)
Bhubaneswar
Mumbai
(Bombay)
Pune
Hyderabad
Vishakhapatnam
Arabian
Sea
Panaji
Bay of Bengal
Bangalore
Chennai
(Madras)
Lakshadweep
Islands
Pondicherry
Andaman
Islands
Port Blair
Cochin
Trivandrum
Nicobar
Islands
Darjeeling
Itanagar
Kohima
Imphal
Aizawl
9000
6000
4000
2000
1000
250
50
0
m
km
0
500
70°
80°
90°
30°
20°
10°


AFGHANISTAN
PAKISTAN
CHINA
NEPAL
BHUTAN
BANGLADESH
MYANMAR
SRI LANKA
INDIAN OCEAN
ARABIAN SEA
BAY OF BENGAL
JAMMU & KASHMIR
Srinagar
Jammu
HIMACHAL PRADESH
Shimla
Chandigarh
PUNJAB
HARYANA
DELHI
Dehradun
UTTARAKHAND
SIKKIM
Gangtok
ARUNACHAL PRADESH
Itanagar
Dispur
ASOM (ASSAM)
NAGALAND
Kohima
Shillong
MEGHALAYA
Imphal
MANIPUR
Aizawl
MIZORAM
Agartala
TRIPURA
Jaipur
RAJASTHAN
UTTAR PRADESH
Lucknow
BIHAR
Patna
JHARKHAND
Ranchi
WEST BENGAL
Kolkata
Gandhinagar
GUJARAT
Bhopal
MADHYA PRADESH
DAMAN & DIU
Daman
Silvassa
DADRA & NAGAR HAVELI
Mumbai
MAHARASHTRA
Raipur
CHHATTISGARH
ODISHA (ORISSA)
Bhubaneswar
TELANGANA
Hyderabad
Yanam (Puducherry)
Panaji
GOA
KARNATAKA
ANDHRA PRADESH
Bengaluru (Bangalore)
Chennai
PUDUCHERRY (Pondicherry)
Mahe (Puducherry)
Karaikal (Puducherry)
TAMIL NADU
KERALA
Kavaratti
LAKSHADWEEP (INDIA)
Thiruvananthapuram
Port Blair
ANDAMAN & NICOBAR ISLANDS (INDIA)


China
Bhutan
Pakistan
Delhi
Nepal
Ganges
India
Myanmar
Mumbai
Bangladesh
Bay of Bengal
Sri Lanka


BRITISH INDIA
1757-1947

THE EAST INDIA COMPANY

- **Gained its charter in 1600 from Queen Elizabeth I**
- **Eventually by negotiation and conquest ruled large areas of India from 1757 until the British Crown took over responsibility for India in 1858**
- **Was the largest trading entity in the world**
- **Its armies from 1858 became those of British India**
- **Its administrative structure was a model for the British and Indian Civil Service**
- **It initiated the process of mapping what it controlled to understand its nature and magnitude**

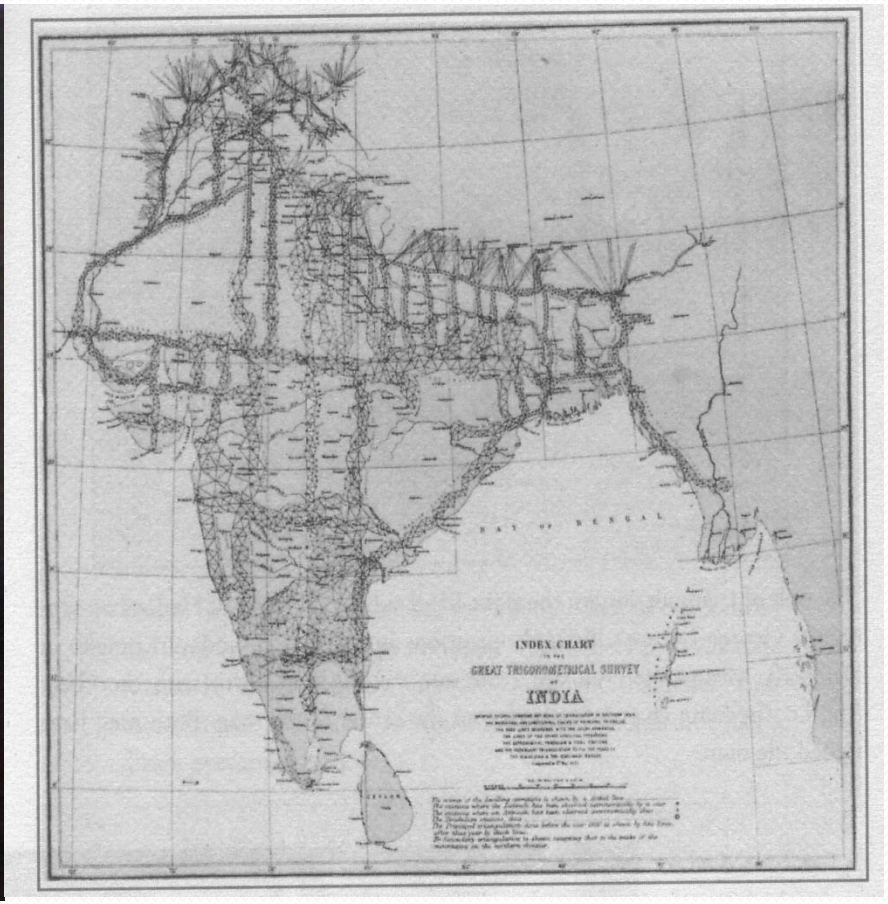
THE BRITISH RAJ

- **The name for British rule in India between 1858 to 1947**
- **Comprising directly controlled provinces and princely states**
- **Overall control was by the Viceroy of India with oversight from a British Cabinet level Secretary of State**
- **The government was keen to develop the economy and integrate the country legally and physically through railways , roads , canals and bridges**
- **A key aspect of this rule was the need to map the extent and details of this major part of the British Empire to gain the understanding and information necessary for effective rule**
- **The primary method of achieving this was :**

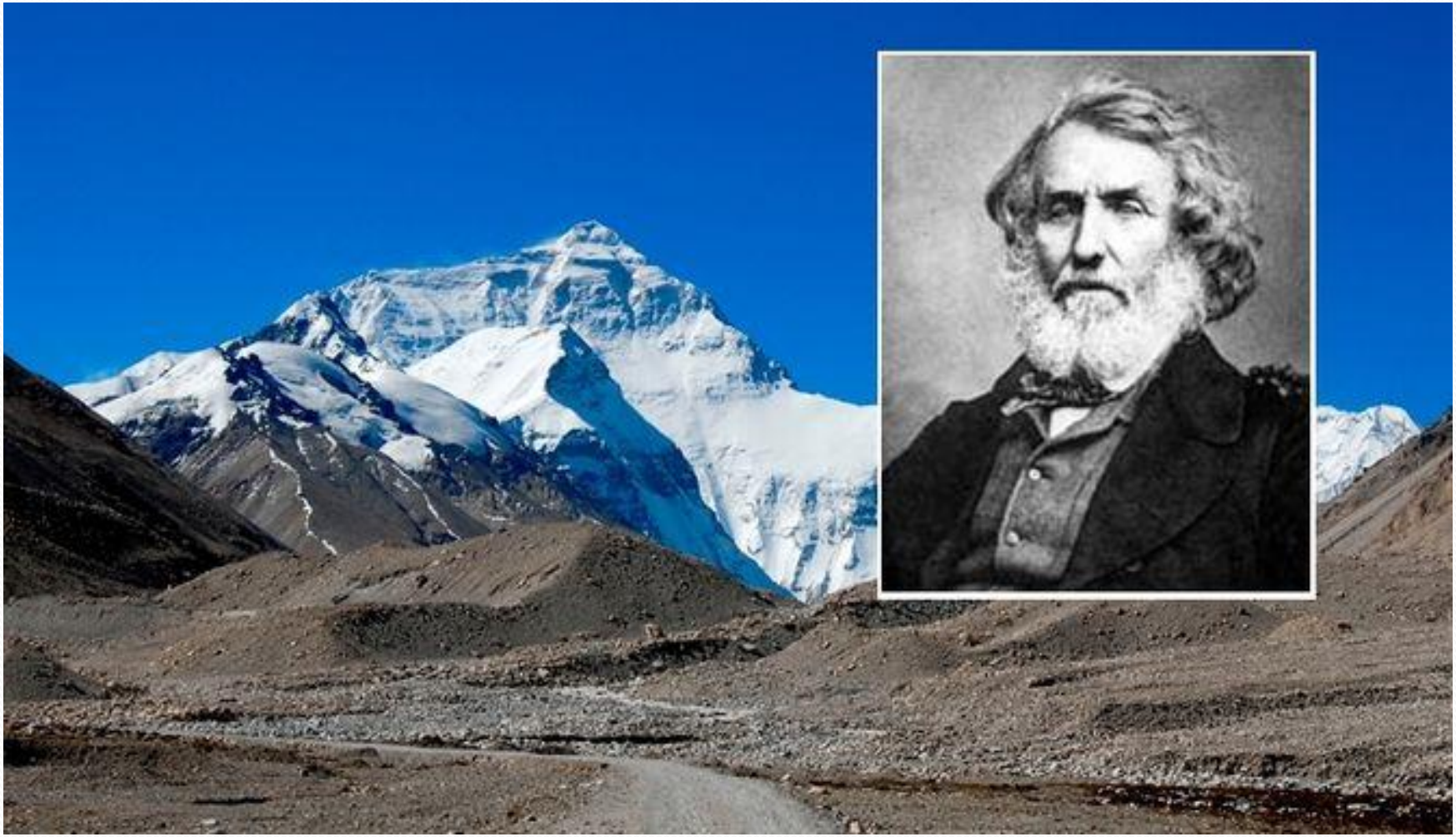

THE GREAT
TRIGONOMETRICAL
SURVEY OF INDIA

- **Started in 1802 under the East India Company**
- **Lasted more than 60 years**
- **At times numbered more than 700 people**
- **The largest and most complex scientific project undertaken globally until the 20th century**
- **Our primary focus is on two key Survey Superintendents ;**

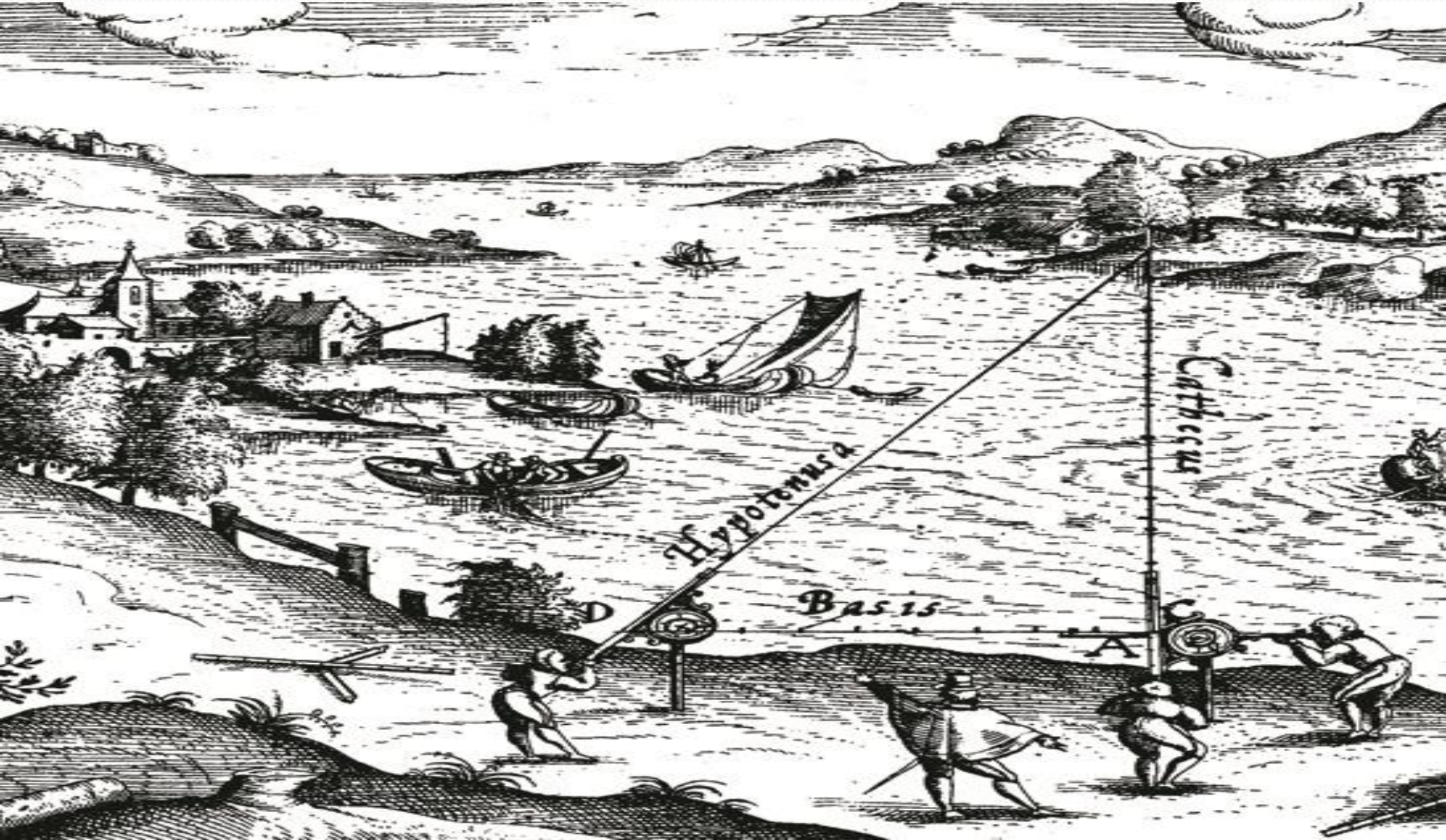
WILLIAM LAMBTON 1802-1823



GEORGE EVEREST 1823-1843



A TRIGONOMETRICAL SURVEY ?



IT'S A BIT MORE COMPLICATED !!

- Establish the base line of a triangle
- Measure it accurately
- From each end measure the angle to a distant point with a theodolite
- Use trigonometry to work out the lengths of the other two sides
- Use one of these lengths as the base line for a new triangle
- Repeat……
- *When complete , rework all the calculations to see if they give the original base line length . If not…*
- Repeat !!

A THEODOLITE

- A telescope with a laser which can move in vertical and horizontal axes
- When pointed at a target object the angle both horizontally and vertically and its distance can be measured with great precision

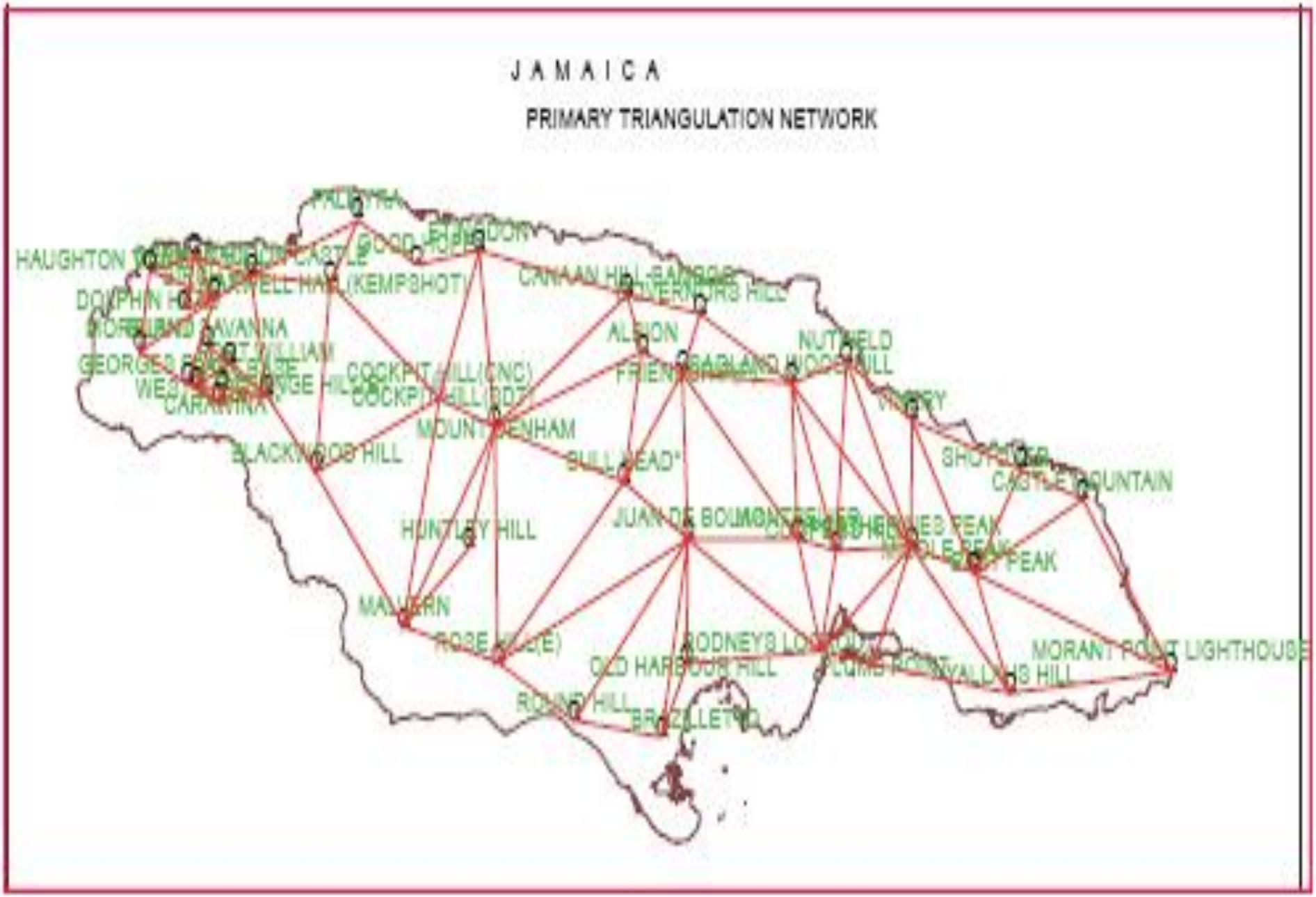


Figure 1 : Jamaica Primary Triangulation Network

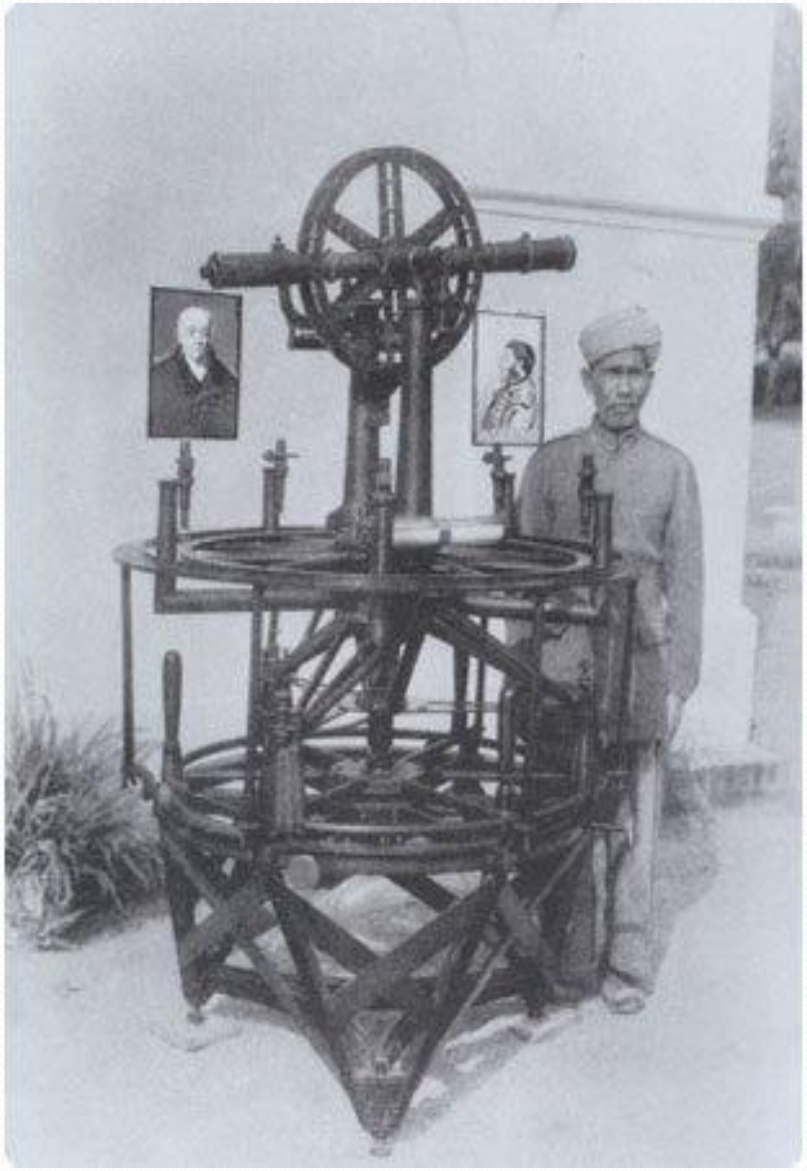
BUT JAMAICA IS NOT INDIA!

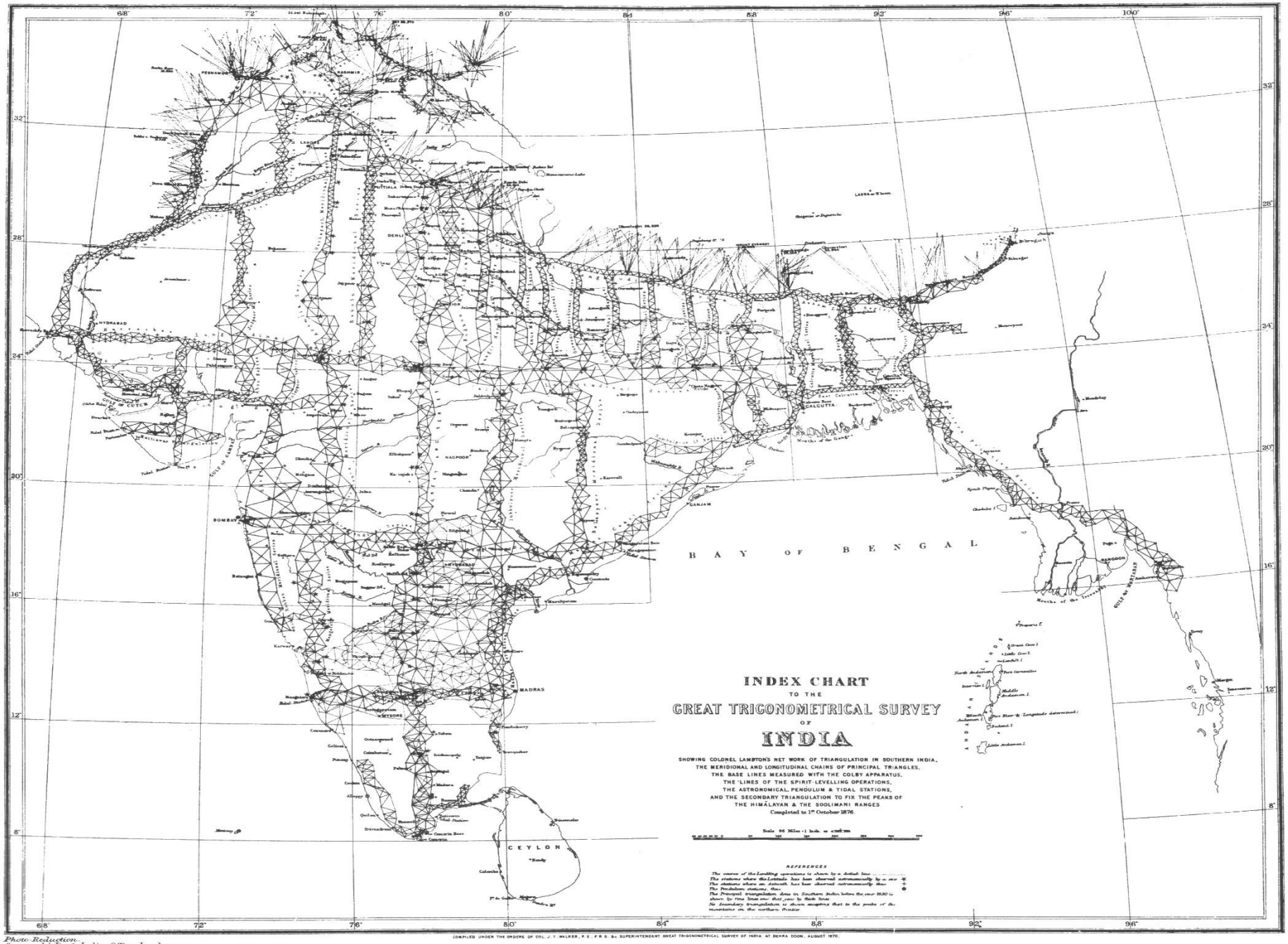
- Jamaica
- 10,990 sq km
- Highest point 2256 metres

- India
- 3,287,590 sq km
- Highest point 8586 metres

INDIAN SURVEY METHOD

- Used triangulation to construct a Great Arc , from South to North
- Used this as a spine from which to develop longitudinal triangulation
- Kept going until the whole of India was covered
- Required the ability to accurately measure distances and also vertical and horizontal angles using a theodolite





COMPILED UNDER THE ORDERS OF COL. J. T. WALKER, F.E., F.R.S. &c SUPERINTENDENT GREAT TRIGONOMETRICAL SURVEY OF INDIA AT DEHRA DOON, AUGUST 1870.

Photo-Reduction
Geograph.l Dep.t India Office, London.

BUT IT'S NOT THAT SIMPLE !

- **Need to take into account the ;**
- ***Curvature of the earth***
- ***Non spherical shape of the earth***
- ***Refraction of light***
- ***Height above sea level***
- ***Gravitational influence of mountains on pendulums***
- ***Temperature***

AND IT CAN BE DANGEROUS !

- Jungles and Rivers
- Valleys , Plains and Mountains
- Heat and Rain
- The Monsoon
- Elephants and Tigers
- Mosquitos and Snakes
- Territorial disputes
- Aggressive villagers
- Not to mention the Indian Mutiny in 1857 !
- And also……


Imperial Russia
Qing Dynasty
Persia
British India
1000 km
stepmap.de


THE GREAT GAME
Britain keeps the Russian bear from India

THE GREAT GAME 1813-1907

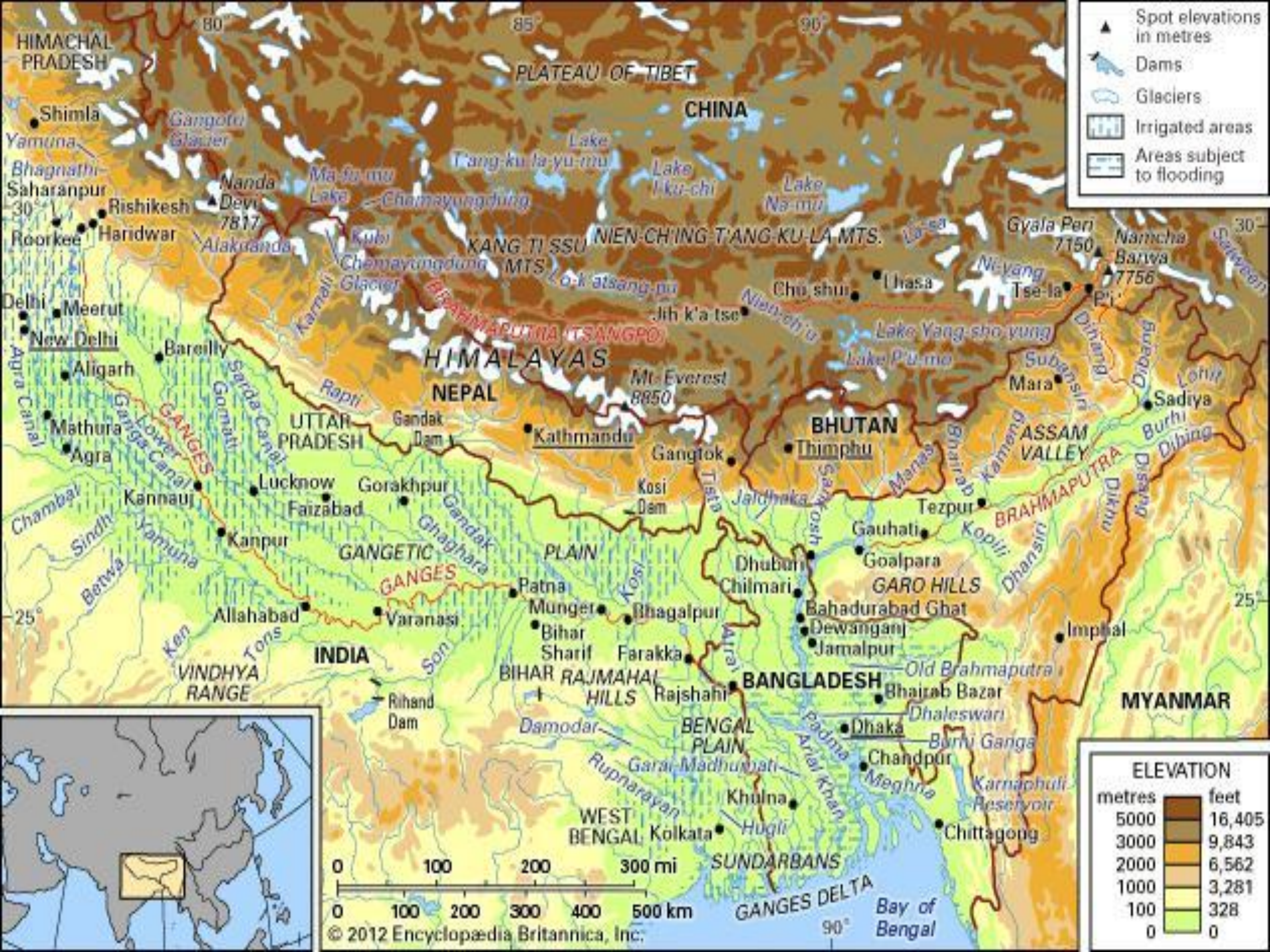
- **The name for the strategic rivalry and conflict between the British and Russian Empires**
- **Russian aggression and influence moved further southward through central Asia towards India**
- **Afghanistan became a key focus of conflict**
- **Geographical knowledge of India and its neighbours became tied in with the need for an understanding of their strength and political and military intentions, in other words "spying"**
- **Key to the achievement of these objectives were the "Pundits"**

THE SAGA OF THE PUNDITS

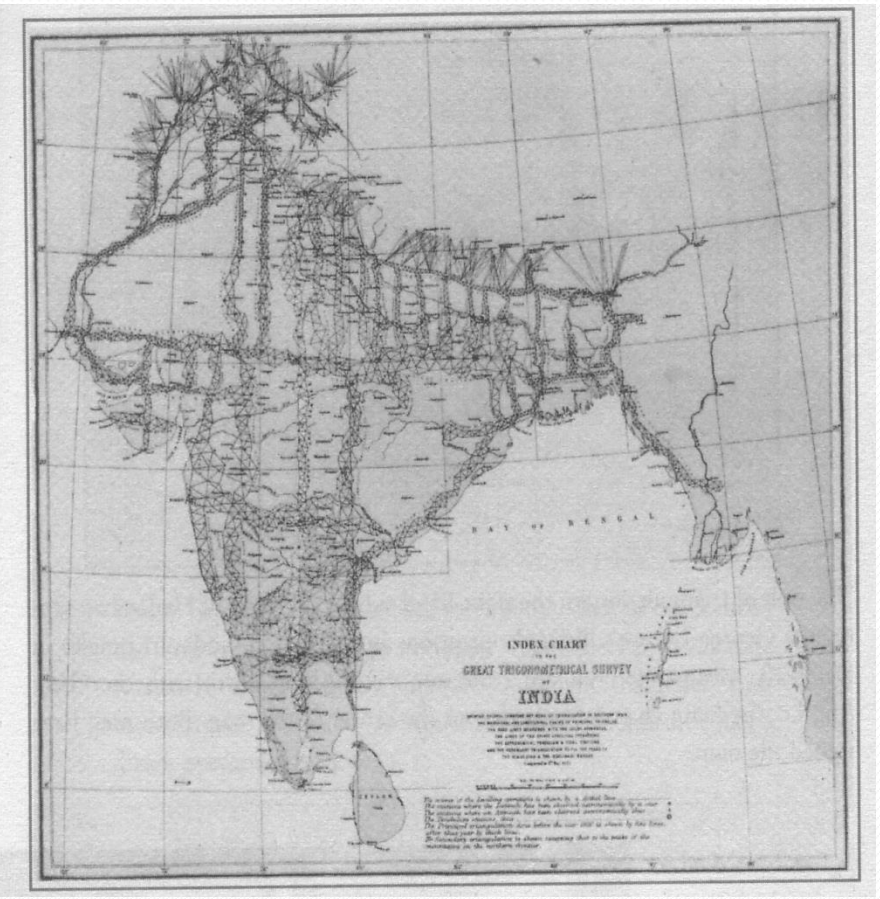
- **Native agents(only 20 in all) used for *route surveys***
- **Paced out terrain at an exact pace (1 mile=2000 paces)**
- **Would disguise themselves often as pilgrims/traders**
- **Carried mapping instruments in their clothing**
- **Hid paper and instruments in their prayer wheels and luggage**
- **Used prayer beads to record the number of paces**
- **Often operating in uncharted and dangerous areas**
- **Nain Singh was amongst the most accomplished**

THE EXPLOITS OF NAIN SINGH

- Born in India 1830 , knowledgeable about Tibet , its language and customs
- Headmaster until 1863 , when selected for training
- Disguised as a merchant went to Kathmandu and Lhasa returning home in 1866
- Carried out further surveys in 1867 and 1874
- Collected innumerable climatic topographical and political details
- Retired and was honoured by many awards including his picture on an Indian postage stamp



WILLIAM LAMBTON



WILLIAM LAMBTON

- Born in England in 1753 the son of a farmer
- Highly skilled in mathematics
- Was a military surveyor in America
- Moved to India under the command of Sir Arthur Wellesley (the future Duke of Wellington)
- Initiated the survey of captured territory
- Was appointed by the East India Company the first Superintendent of the Trigonometrical Survey in 1802
- Continued and developed the Survey until his death in India in 1823

LAMBTON'S SURVEY

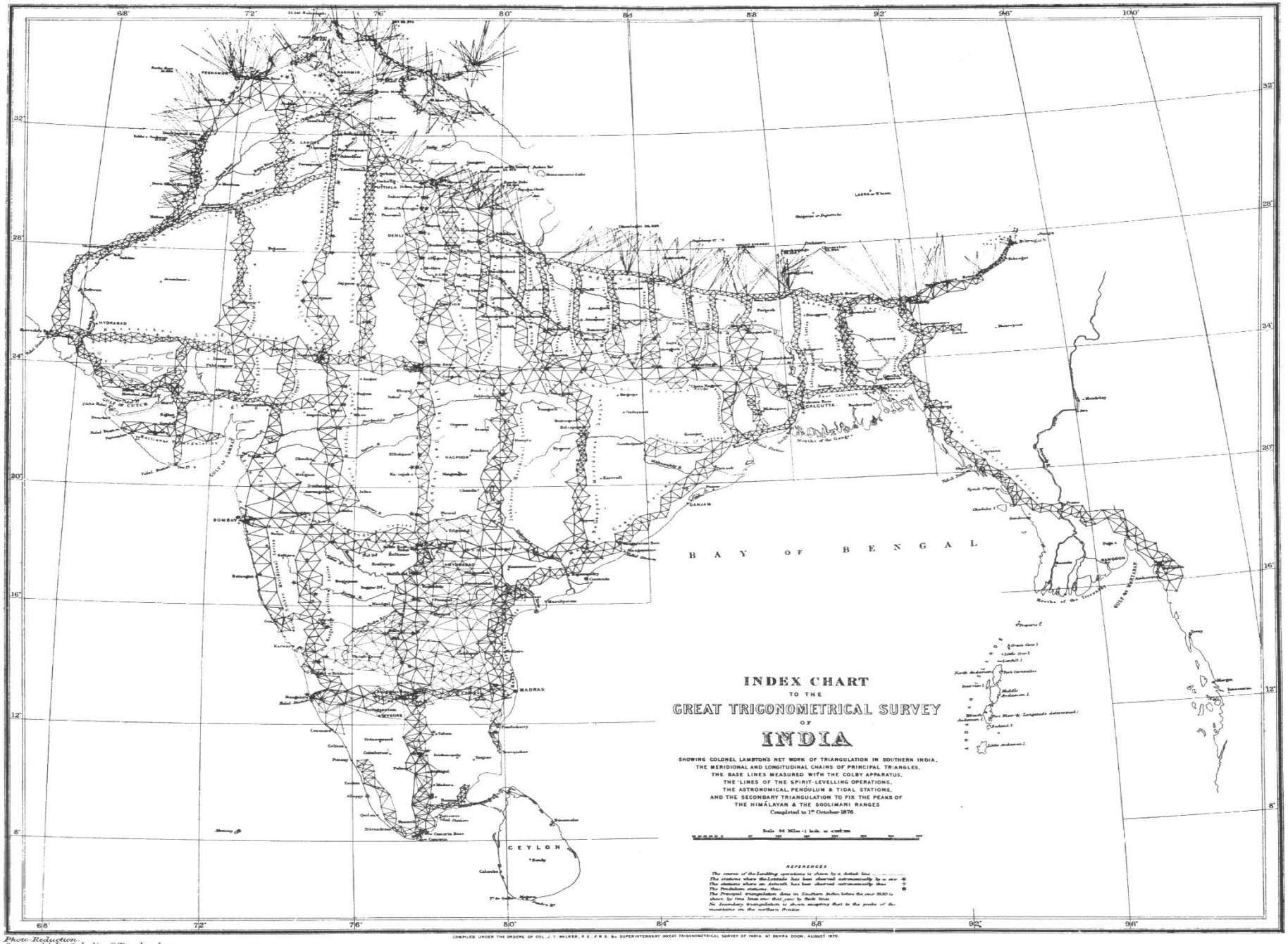
- **Started in Tamil Nadu in South India with the measurement of a base line**
- **Seven and a half miles long metal chain**
- **Required 400 measurements**
- **Took 57 days**
- **In temperatures varying from 80 to 120 degrees Fahrenheit !**
- **Involving temperature adjustments of 7 thousandths of an inch for each hundred foot surveyed**
- **Height above sea level had also to be determined**
- **He could then move on to Central India , but……**

A DROOG WITH A VIEW

- **The plains of Central India are flat and dusty , not good for surveying**
- **Lambton made use of isolated large hills called droogs to get improved visibility and a further horizon**
- **But droogs are not always in the right place so temples were used**
- **In one such episode a theodolite was hauled to the top of a 220 ft temple , but came crashing down !**
- **Lambton had it repaired and a replacement procured at his own expense**

LAMBTON'S ACHIEVEMENTS

- **Completed the southern half of the Great Arc and most of southern India**
- **Justified the scientific validity and economic benefits of his work to both administrators and scientists**
- **Produced copious and authoritative papers on geodesic surveying**
- **Won academic distinction with the French Institute and the Royal Society**
- **Loved India and was buried there but in an unknown grave**



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Geograph.l Dep.t India Office, London.

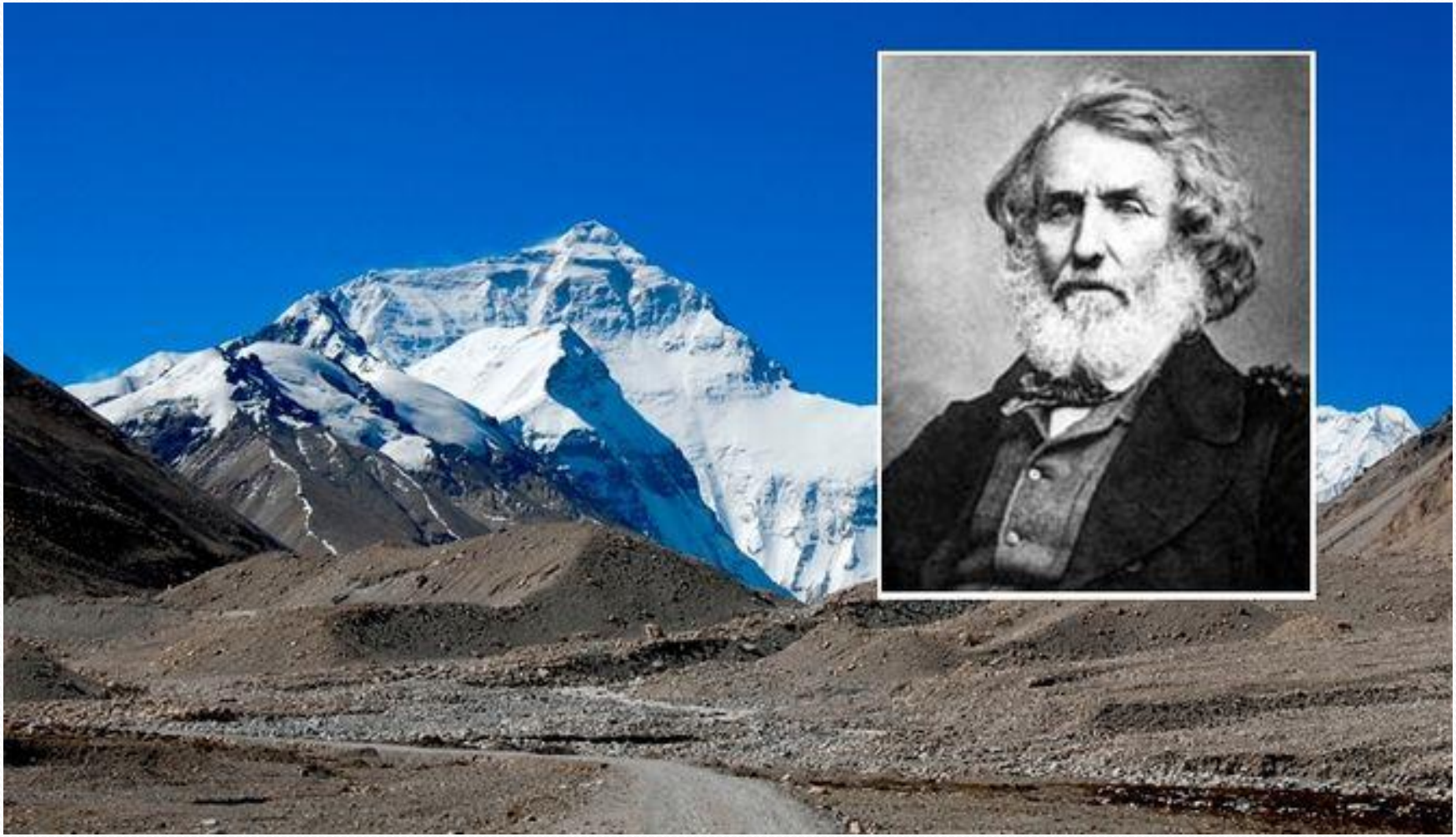
LAMBTON'S CHARACTER

- ***"Colonel Lambton was not a man to be overawed by trifles or to yield.....without a struggle***
- ***He seemed a tranquil and good humoured person ...but when he roused himself...his native energy appeared to rise superior to all infirmities...and his high forehead gave animation and dignity to a countenance beaming with intellect and beauty***
- ***I shall never forget the impression which this far famed geodesist made on my mind"***
- **George Everest**

HIS SUCCESSOR

- ***"I sincerely hope that after I relinquish the Survey some one will be found possessing zeal, constitution and attainments to prosecute it on the principles already followed . It would be gratifying if I could entertain a hope that the work which I began should at some future date be extended over British India"***
- **George Lambton**

GEORGE EVEREST



GEORGE EVEREST

- Born in Wales in 1790
- Commissioned into the Royal Artillery in 1818
- Appointed assistant to William Lambton
- Succeeded Lambton as Superintendent in 1823
- Was appointed Surveyor General in 1830
- Retired in 1843 and returned to England
- Was knighted , made a Fellow of the Royal Society and Vice President of the Royal Geographical Society
- Died in London in 1866

EVEREST'S SURVEY

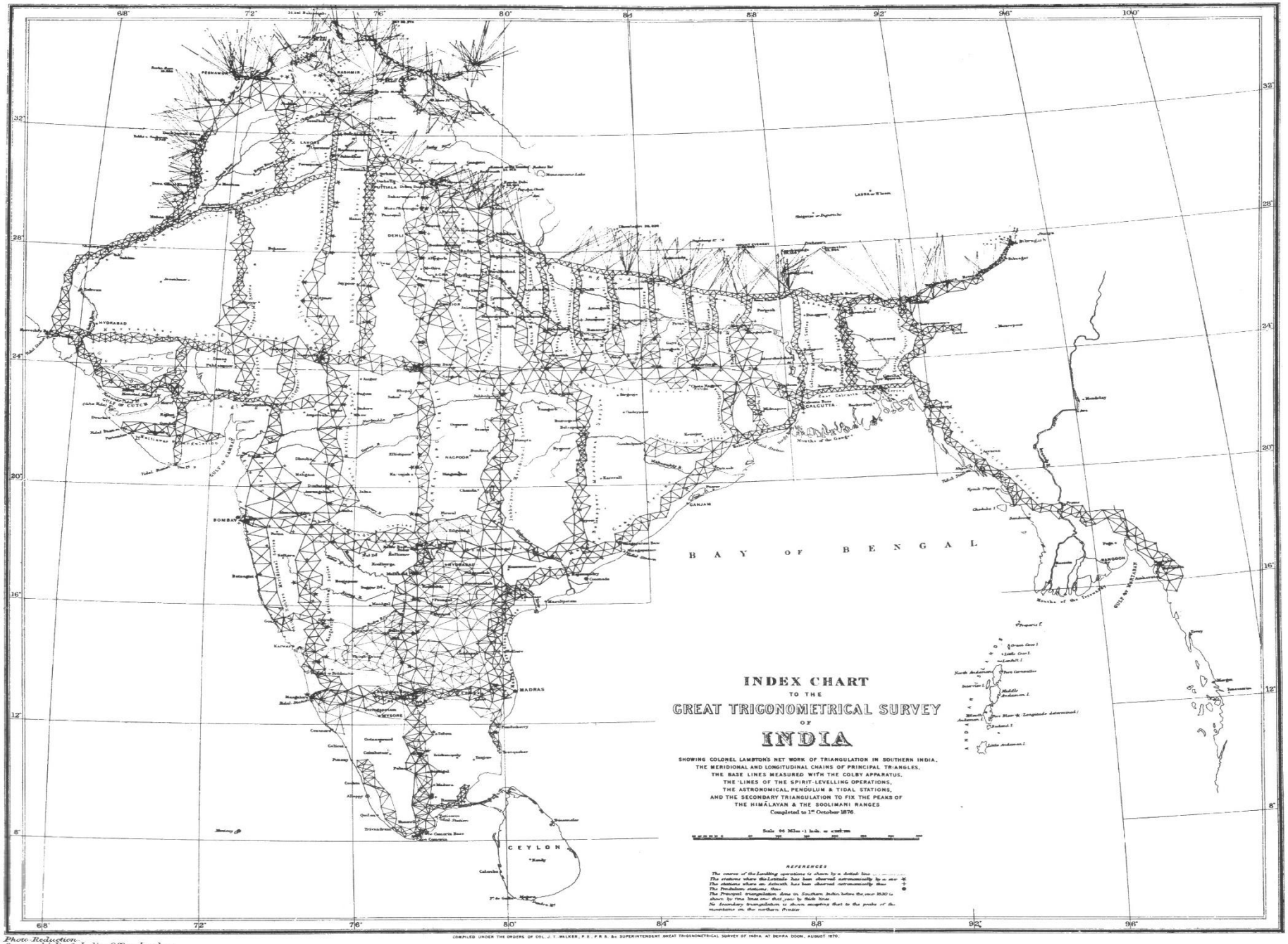
- **Took over from Lambton in 1823**
- **Continued the extension northwards of the Great Arc**
- **Spent seven years from 1825 recuperating in England**
- **Continued and completed the Great Arc survey from 1832-41**
- ***"The whole Indian Arc from Cape Comorin to the Himalayan Mountains a distance of 1500 miles was thus completed"***

EVEREST'S CHARACTER

- **Highly energetic and aggressive**
- **Demanding of subordinates and intolerant of incompetence**
- ***"You all seem to be stark staring mad…unless I receive assurance that you will not play the fool again I shall adopt strong measures to you"***
- **Demanding of himself**
- ***"On some occasions my state of weakness has been such that without being held up I could not have operated the Great Theodolite"***

EVEREST'S ACHIEVEMENTS

- Introduced luminous signals to be used at night rather than flags and beacons during the day
- Built a chain of towers to improve daytime viewing
- Introduced the gridiron system where an arc along a line of latitude was the spine from which a grid of arcs at right angles could be produced
- Built up local resources in the areas of computation and instrument making
- Established a competent organisation
- Made a substantial contribution to the science and geographical knowledge of India



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MAKING SENSE OF THE NUMBERS

Coordinate Conversion: Cartesian (ECEF X, Y, Z) and Geodetic (Latitude, Longitude, and Height)

Direct Solution for Latitude, Longitude, and Height from X, Y, Z

This conversion is not exact and provides centimeter accuracy for heights < 1,000 km
(See Bowring, B. 1976. Transformation from spatial to geographical coordinates. Survey Review, XXIII: pg. 323-327)

$$\phi = \text{atan}\left(\frac{Z + e'^2 b \sin^3\theta}{p - e^2 a \cos^3\theta}\right)$$

$$\lambda = \text{atan2}(Y, X)$$

$$h = \frac{p}{\cos(\phi)} - N(\phi)$$

where:

ϕ, λ, h = geodetic latitude, longitude, and height above ellipsoid

X, Y, Z = Earth Centered Earth Fixed Cartesian coordinates

and:

$$p = \sqrt{X^2 + Y^2} \qquad \theta = \text{atan}\left(\frac{Za}{pb}\right) \qquad e'^2 = \frac{a^2 - b^2}{b^2}$$

$N(\phi) = a / \sqrt{1 - e^2 \sin^2\phi}$ = radius of curvature in prime vertical

a = semi-major earth axis (ellipsoid equatorial radius)

b = semi-minor earth axis (ellipsoid polar radius)

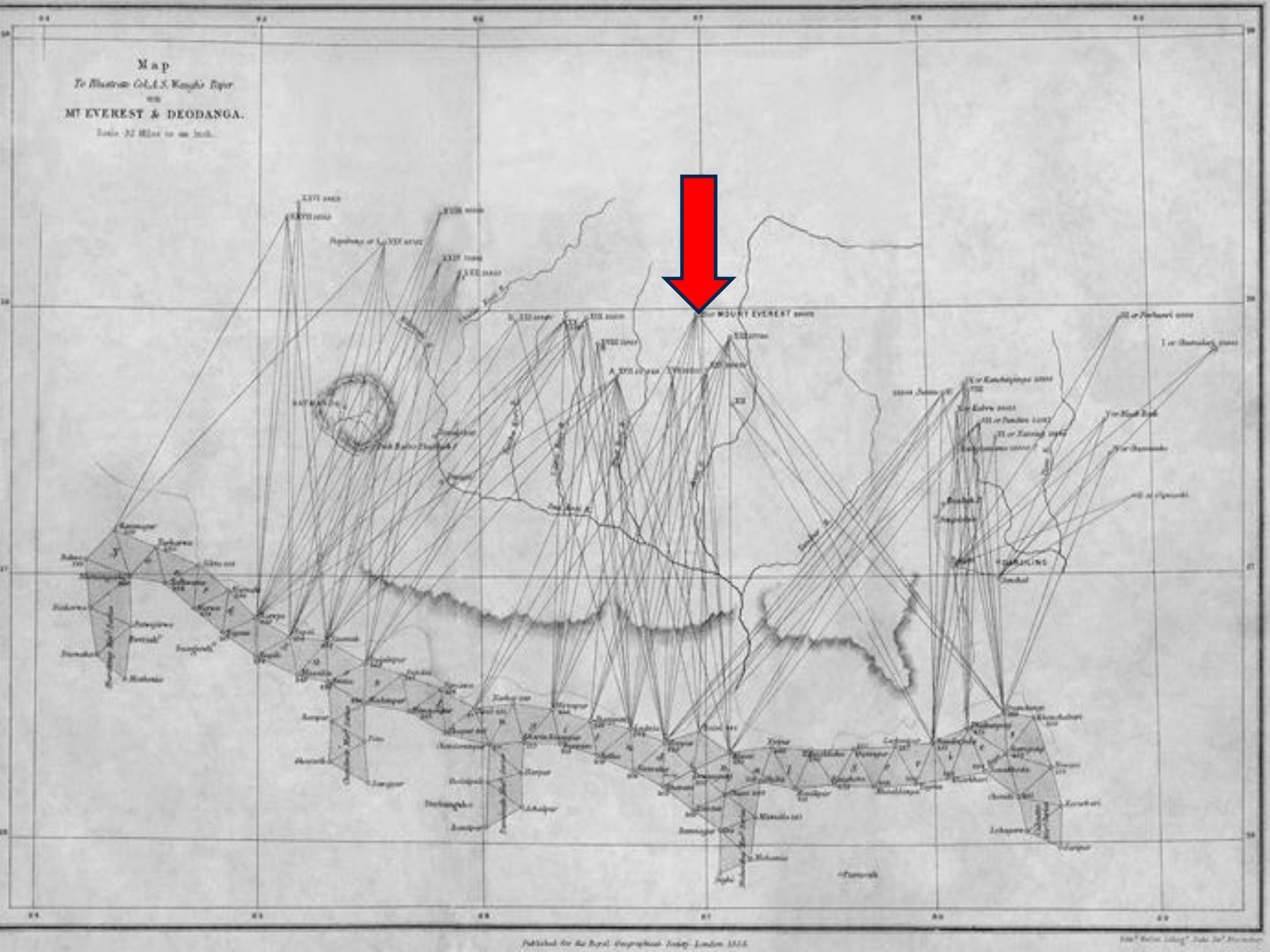
$f = \frac{a - b}{a}$ = flattening

$e^2 = 2f - f^2$ = eccentricity squared

- Radhanath Sikdar
- Mathematical prodigy
- Became Chief Computor
- Highly innovative
- Carried out the most complex calculations known before the computer age
- Confirmed that Mt Everest was the world's highest mountain

EVEREST'S SUCCESSORS

- His immediate successor was Andrew Waugh who from 1843 to 1861 significantly extended the Survey coverage
- He determined the heights of 79 Himalayan peaks including Peak XV which he named Mt Everest
- Under his successors the Survey was eventually completed in 1871
- The surveying organisation became The Survey of India which is the oldest scientific department of the current Government of India


Map
To Illustrate Col.A.S. Waugh's Paper
on
Mt EVEREST & DEODANGA.
MOUNT EVEREST
Published for the Royal Geographical Society London 1858.

THANK YOU FOR LISTENING, ANY QUESTIONS?