THE HIMALAYAN GEOSYNCLINE

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The question whether the entire body of the Himalayan orogen, with its remarkably persistent orographic axis from Kashmir to Assam, over 1,500 miles long, has resulted from the uplift of marine geosynclinal deposits, is discussed in this paper. The physiographic extent and the disposition of the Tethyan geosynclinal deposition-basin from Hazara to the borders of Burma, forming the Tibetan zone of the Himalayas, constitute only a part of this mountain chain; they have a distinct strike, which runs co-axial with the main Himalayan strike from Assam to W. Kumaon, from where it departs from the latter. The geosynclinal strike line crosses the Central Crystalline Himalayan axis from north to south at Kargil and pursues a southern course towards the Punjab Salt Range, while the latter persists in its NW trend towards Gilgit and Nanga Parbat. The marine geosynclinal sediments therefore compose only the northern ranges of the eastern Himalayas and parts of Kashmir and Hazara ranges south of the summit zone. The bulk of the mountains from Kumaon eastwards lying to the south of the crestal axis as well as the northern Kashmir Himalayan ranges are composed of rocks of pre-Cambrian *Purana* facies belonging to the southern Gondwana Continent which acted as the foreland. The western and the eastern extremities of the Himalayan chain terminating in two remarkably acute syntaxial bends to the south carry elements of Tethyan geosyncline.

The mountain ranges of the Earth have originated through the uplift of geosynclines. This is a textbook aphorism, adopted from E. Haug after he had given shape to the prevailing concepts on the subject in 1900, and we might examine here how far it applies to the Himalayas. Geosynclinal belts are the weaker parts of the Earth's Crust, it is here that the greater part of the Earth's diastrophic energy is spent. It is these loaded and consequently weakened zones that are ridged up into mountain chains by lateral compression during the periodic mountain-building revolutions of the Crust. The most important of these in Earth's history since the Palaeozoic are the *Caledonian* (late Silurian), the *Hercynian* (Permo-Carboniferous), the *Laramid* (Cretaceous) and the *Alpine-Himalayan* (middle and late Cenozoic). But not all mountain-systems of the world are 'geosynclinal prisms'. Many mountains are so, in whole or in part. There are mountain chains, however, that have arisen through orogenic or epeirogenic forces operating on areas that were not loaded with thick sea deposits; and there are geosynclinal deposits that have not been uplifted into mountains.

According to current ideas, the body of the Himalayas was built on the floor of a great ancient Mediterranean Sea, the *Tethys* (the present Mediterranean is only a small remnant of that sea), that prevailed from the end of the

Palaeozoic to early Eocene, extending from Central Europe right up to China. Over 30,000 feet of sediments were deposited on this sea floor separating the Eurasian Continent of the North Angaraland from Gondwanaland—the land which stretched from Africa to Australia and included part of the Antarctica, which bordered it to the south. As these deposits grew thicker and heavier, the sea bottom kept sinking. Ultimately a limit was reached, when no further sinking was possible (because of the limit of the heat of the rising isogeotherms and the counter-pressure of the semifluid or plastic layers—the Upper Mantle of the subcrust) and this great overloaded trough underwent a set of reverse phenomena, whereby after a considerable amount of compression, involving fracture and shearing, it was uplifted into a mountain system. This is the idea of a geosynclinal mountain. There exist differences of opinion over the areal extent and trend of the geosyncline described above and over its correspondence with the main body of the Himalayan orogen. There are some who believe that there are two parallel geosynclines separated by a sharp geanticlinal flexure. Others think that there is implied one incomplete and greatly disrupted geosyncline—the present Tibetan or Tethyan zone of marine sediments. Detailed surveys and mapping covering wide areas of southern Tibet and the mid-Himalayan zone alone will settle these points. It is, however, evident that the Himalayan geosyncline does not fit into the present-day concept of eugeosyncline or mio-geosyncline.

Before we review the physiographic extent and disposition of the Tethyan geosyncline from Hazara to the borders of Burma, we must have a clear conception of the geographic limits of the orogen that is named Himalaya (Burrard 1934). Then alone can we appreciate how much of the orogen is of marine geosynclinal constitution. The southern limit of the Himalayan geosyncline from Waziristan through Hazara and Kashmir up to Western Kumaon is clear and well defined by its over-thrust on the Outer Himalayan Upper Tertiary zone, which has long been recognized as the Main Boundary Fault. The region of West Kashmir lying within this boundary was a dry area and acted as a narrow land-bridge between the Gondwana Continent and Angaraland during the greater part of the Palaeozoic. In the Permo-Carboniferous, it was flooded by the Tethys, but even then up to the Trias, it was an archipelago of actively erupting volcanic islands on which there were transgressions of Gondwana sediments, with their characteristic land plants, from the foreland to the south.* From Nepal to Bhutan, the southern boundary is ill-defined, as the observed geosynclinal deposits are few and not clearly identifiable, though this ground is not yet fully surveyed. Further east, the entire stretch of Assam Middle Himalayas is yet geologically *terra incognita* and is a blank on the Himalayan Map. With respect to the northern border of the

* D. N. Wadia—The Palaeogeography of Kashmir during the Permo-Carboniferous Age, XVII International Geological Congress, Moscow, Vol. I, 1937.

Mesozoic Himalayan sea, there are hardly any data; it is yet highly uncertain and cannot be known without accurate mapping in Tibet. Only the north-western sector of this border is marked and delimited, as it skirts the southern flank of Nanga Parbat and extends westwards along the tip of Kagan and Hazara. In the region between Rupshu and Kargil to Burzil, we have only the faulted Cretaceous Flysch border (with its fringe of the Eocene in Ladakh) to go by. Further east, the Kailas range, abutting on the Trans-Himalaya with Manasarovar and the Rakas Tal lakes at its foot, probably defines this part of the border, though greatly disrupted by faulting. Still further east, through north of Nepal, Sikkim and Bhutan to Assam, the north limit of the Himalayan sea or its system of deposits is a sheer conjecture. How far north did the Himalayan sea spread over Tibet? A more relevant question would be what was the northern limit of the geosynclinal deposits laid down in this sea? It is probable that this border is tectonic and that it has been brought closer to the Plains of India, by a strike fault that has disrupted a good part of the Tibetan limb of the geosyncline. The 'Kiogarh Exotic blocks' of Johar on the Tibetan border of Kumaon are pointers to this fault. They are the relicts, as 'klippen' and transported blocks, from Permian, Triassic and Jurassic formations constituting the north limb of the geosyncline. A considerable width of this flank of the geosyncline is thus missing through fault subsidence. For the Assam Himalayas north of the NEFA, there are no data whatever on this point in the absence of any geological maps.

The association of Talchir (Lower Gondwana) boulder-bed and beds carrying the typical *Gangamopteris*, with marine fossiliferous strata, in various parts of the Middle Himalayas extending from Simla to the extreme end of Assam (and even across the Central Axial Range, in the south-east Karakoram), according to Norin (1946), suggests the contiguity of the edge of the Gondwana foreland to the Himalayan geosyncline.

The point next to be considered is: What are the farthest eastern and western geographical limits of the Himalayan orogen, and of the sea from which it originated? It was formerly thought that the Himalayas ended to the west at Nanga Parbat peak (26,620 ft.) at the southward bend of the Indus and to the east at Namcha Barwa peak (25,445 ft.) at the southward turn of the Brahmaputra. The detailed survey and mapping carried out during the years 1921–29 in the former area has showed that this is not a fact and that the system extends much beyond the Indus and that it undergoes a sharp deflection of its axis. There is observed at this point the striking phenomenon that these mountains, after following a persistent north-westerly strike of over 1,600 miles, take, on nearing Burzil Pass, a sharp turn northward—a 66-mile long hair-pin bend round Nanga Parbat, turning back south acutely towards Hazara. The cause of this is believed to be the obstruction of the nail-like

Punjab promontory of the Deccan shield to the south-verdant earth-waves emerging from the sea floor under the compressive forces of the newly-rising mountain system (Wadia 1931). All the formations on the east of Nanga Parbat are reflected westwards with their tectonic relationships, fold by fold, thrust by thrust, in Hazara. This Himalayan *syntaxis*, as the knee-bend in the mountains is called, is a well-established tectonic feature of the NW Himalayas. It has affected the courses of all its constituent ranges from the Pamirs to the Potwar basin of Siwalik foothills—a total meridional distance of 300 miles in conformity with its morphogeny. From Hazara, the new trend can be traced further to south and west to the Suleiman Range in East Baluchistan. It was formerly believed by some eminent geologists that the Himalayan chain, after crossing the Indus, extended westwards through Badakshan and Afghanistan to Russian Turkistan.

Similarly the eastern Himalayas were believed to have extended across the Brahmaputra through Yunan to China. Several geographers have advanced this view in their writings. But here also, though evidence from detailed mapping and stratigraphic and tectonic work is lacking, there are grounds for believing from the disposition of trend-lines of the Assam-Burma ranges that there is the same acute syntaxial bend of the Himalayan rock formations to the south. The Himalayas, therefore, do not terminate at the Indus bend or (with a less degree of probability) at the bend of the Brahmaputra, but extend southwards at either extremity. But how far they do so, we do not know yet, in the absence of definite surveys or maps of this region. Whether the mountains of the Andaman and the Nicobar islands belong to the Himalayan orography, we do not know; but about the Suleiman Range, we have some positive data, obtained through some old geological maps, suggesting that the elements of Himalayan orography pass on to Suleiman Range, though greatly reduced in thickness. This, in broad outline, summarizes our existing knowledge about the Tethys geosyncline and its relationship to the Himalayan orogen and to the Gondwana Continent.

It is apparent that the geosyncline, we have outlined above, does not correspond, in its area or configuration, to the orographic block of the Himalayas. It forms only a part of that orogen. A singular lack of coincidence also exists between the orographic axis and the geosynclinal axis. While the chain of high elevations from Nanga Parbat in Kashmir to Namcha Barwa in Assam, building what has been designated the Great Himalayan Range, denotes the main Himalayan protaxis, the axis of the Tethyan geosyncline takes a different course and cuts across the former near Kargil. The main pile of the Tethyan (Tibetan zone) sedimentary systems lies to the north of the protaxis in the eastern two-thirds of the chain, whilst in Hazara-Kashmir the fossiliferous sedimentary systems of the Tibetan zone are totally absent in the north and are all confined to its south.

Geographers, especially the Survey of India, have done remarkable work in the last century and have given us a correct outline of the morphology, length and breadth of the main Himalayan range and its component longitudinal subordinate ranges of more or less concordant strike—a crustal block—1,500–1,600 miles long and 150–250 miles wide (Burrard and Heron 1934). The orographic axis of this composite chain of elevations runs along the crest-line of the Central High Peaks, but that is definitely not the axis of the vast synclinal system of marine deposits, laid down from early Palaeozoic to the middle of the Eocene. From Assam to Almora, the orographic and the geosyntaxial axes keep together, both on the Tibetan side and on the Indian flank of the central crest-line; but near Kargil there is a break and the Himalayan axis departs from the axis of the geosyncline. The latter turns south-westwards and after crossing the former it overspreads the Kashmir-Hazara region, terminating at the Salt Range. The orographic axis, the main line of crustal uplift, on the other hand, persists in its north-western course up to Gilgit, the apex of the Kashmir syntaxis, and impinging on the southern flank of the Karakoram-Hindu Kush-Pamir Complex it turns round to the south after crossing the Indus. The cis- and trans-Indus mountains involved in this are clearly not part of the marine geosynclinal that we are considering here; they are built of rocks of the Purana and Gondwana Continental facies of the Deccan Peninsula.

The Tibetan (Tethyan) zone of geosyncline widens considerably, as it crosses the crestline and overspreads Kashmir and Hazara territory, terminating at the Salt Range. While the Hazara stratigraphy is a replica of the Kashmir formations seen on the east flank of the syntaxis, it is not easy to fit in the Salt Range within the stratigraphic pattern of the Tibetan zone. The Salt Range may be regarded as a monoclinal upthrust extremity of the Himalayan geosyncline against the Punjab plains, containing a replica of the Palaeo-Mesozoic formations, such as are witnessed in the Pir Panjal Range. Though the Salt Range mountains physiographically can be regarded as having only a remote connection with the Himalayas, they are morphogenetically linked with the Himalayan orogeny, especially with that of the Hazara sector. The materials of the Salt Range were laid down interruptedly in a distant bay of the Tethys and there is no clear apparent affinity, either lithological or faunal, except in the Permo-Trias and in the Eocene systems. The earlier Tertiary phases of the Himalayan uplift did not materially affect the Salt Range, but the later Pliocene and Pleistocene phases of the orogeny swept the entire pile of Cambro-Eocene strata, with their superposed load of 20,000 ft. of the Siwalik deposits (the post-geosynclinal molasse) on the north flank, and folded them into the Jura type of mountains.

The Himalayan geosyncline from Assam to its north-western extremity in Hazara is one single homogeneous, though broken and interrupted, unit with one consistent winding axis. There is no evidence that the bio-stratigraphic differences, so strikingly observed between the richly fossiliferous Tibetan zone and the almost barren synchronous Mesozoic deposits of the Middle Himalayas (the Krol-Tal systems), across the crest zone, imply their origins in two parallel seas. The observed differences can be explained on regional or edaphic grounds. It appears that a geanticlinal bulge in the wide synclinal basin of the Tethys, east of Garhwal, interposed a biological barrier, preventing free migration of life between the Tibetan portion of the waters and the waters on the Indian side and that a branch of this geanticline within the geosyncline separated the Spiti basin from the Kashmir basin. The now separate basins of Tibetan zone sediments, found in Sikkim-Bhutan, Nepal, North Kumaon, Spiti and Kashmir, were originally one continuous belt of deep water deposits. They are now disconnected due to warps in the geanticlinal axis at the time of their uplift. They have also undergone tectonic disturbances of varying degrees, as for example, while the Kashmir and Hazara Palaeo-Mesozoic basins are composed of simple undisturbed folds, their contemporaries in Nepal, Sikkim, Bhutan and the North Kumaon areas show a high degree of plication, flexure and thrust. The Tethyan geosyncline is widest at its north-west end, but, towards the east, it greatly diminishes in width, most probably due to disruption caused by strike faulting.

The rise of the Himalayan orogen from the Tethyan waters in the three-phased Tertiary uplifts must have involved crustal upheaval and fold-waves ranging over 8 miles in vertical amplitude. The limestone strata laid down on the sea floor, containing assemblages of foraminifers, molluscs and ammonites are today observed at elevations of 28,000 ft. and upwards on the crest of the Central Crystalline Range. This uplift, besides elevating the floor of the geosynclines, also encompassed a considerable extra-Tethyan terrain covering Assam, Ladakh, Baltistan and Gilgit. The latter three constitute the Kailas and the Ladakh ranges pressing against the south flank of the Karakoram-Hindu Kush and curving them into a broad arch. The wide area of crystalline and metamorphic rocks forming the Nanga Parbat massif, Gilgit and Ladakh as well as Assam are a part of the Deccan horst; they exhibit distinct Purana and Gondwana facies rather than the Tibetan.

To what extent, therefore, the Himalayas can be regarded as a geosynclinal type of mountain range, will be determined, when detailed surveys have thoroughly analysed and revealed the true constitution of the crystalline rock-complexes of the Middle Ranges. It is possible that this vast terrain of barren crystalline, metamorphic and migmatized rock, stretching from East Punjab to Assam may enclose some obscure basins of altered marine Tethyan elements, hitherto unrecognized, besides the few known Krol-Tal basins.

The Himalayan orogen, unlike its contemporaries the Alps, the Rockies, the Andes and the other circum-Pacific mountain ranges of late Tertiary

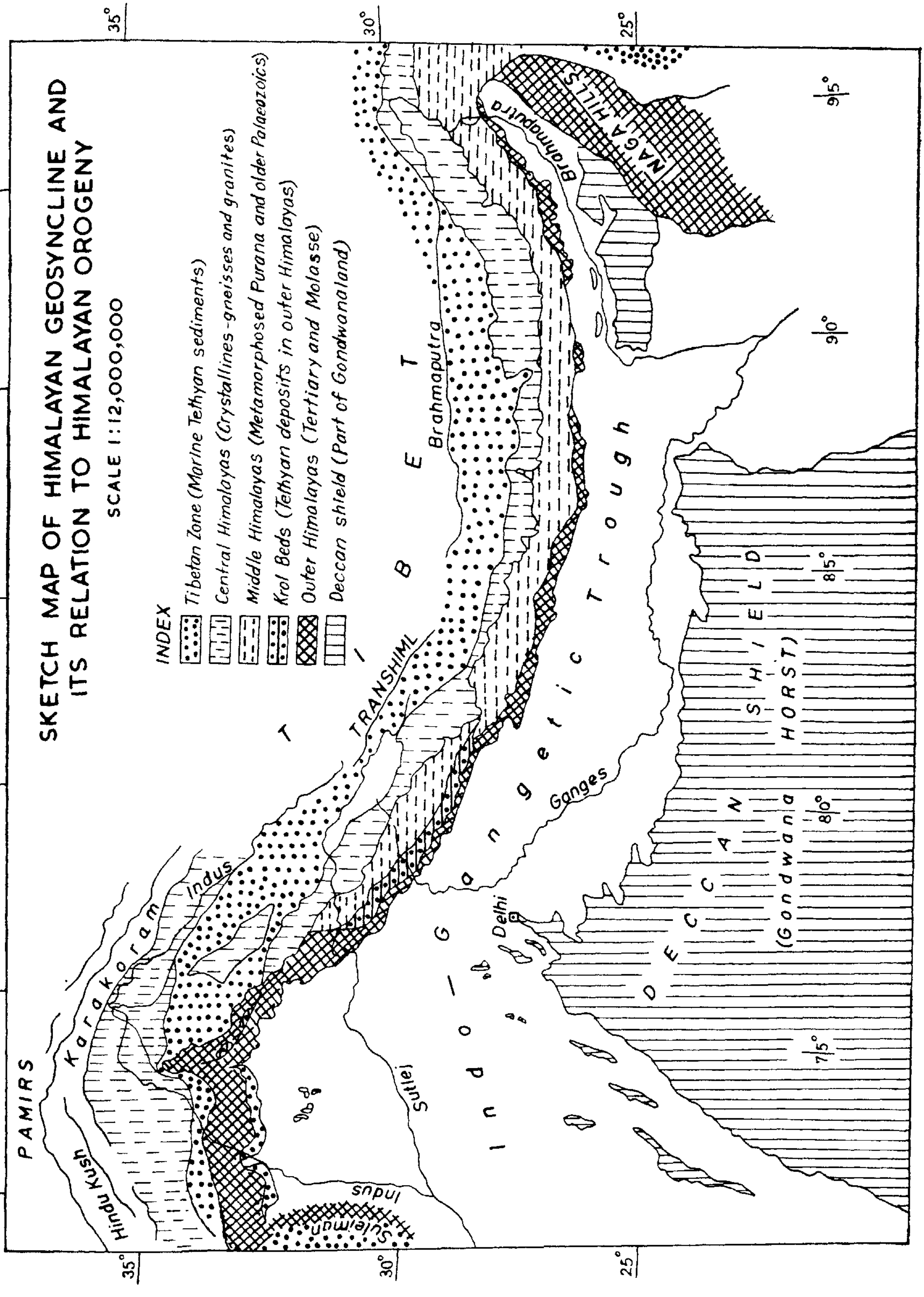
SKETCH MAP OF HIMALAYAN GEOSYNCLINE AND ITS RELATION TO HIMALAYAN OROGENY
SCALE 1:12,000,000
INDEX
Tibetan Zone (Marine Tethyan sediments)
Central Himalayas (Crystallines-gneisses and granites)
Middle Himalayas (Metamorphosed Purana and older Palaeozoics)
Krol Beds (Tethyan deposits in outer Himalayas)
Outer Himalayas (Tertiary and Molasse)
Deccan shield (Part of Gondwanaland)
PAMIRS
Hindu Kush
Karakoram
Indus
Suleiman
Sutlej
T I B E T
TRANSHIML
Brahmaputra
NAGA HILLS
Indo-Gangetic Trough
Ganges
Delhi
DECCAN SHIELD HORST
(Gondwana
35°
30°
25°
70°
75°
80°
85°
90°
95°

FIG. 1.

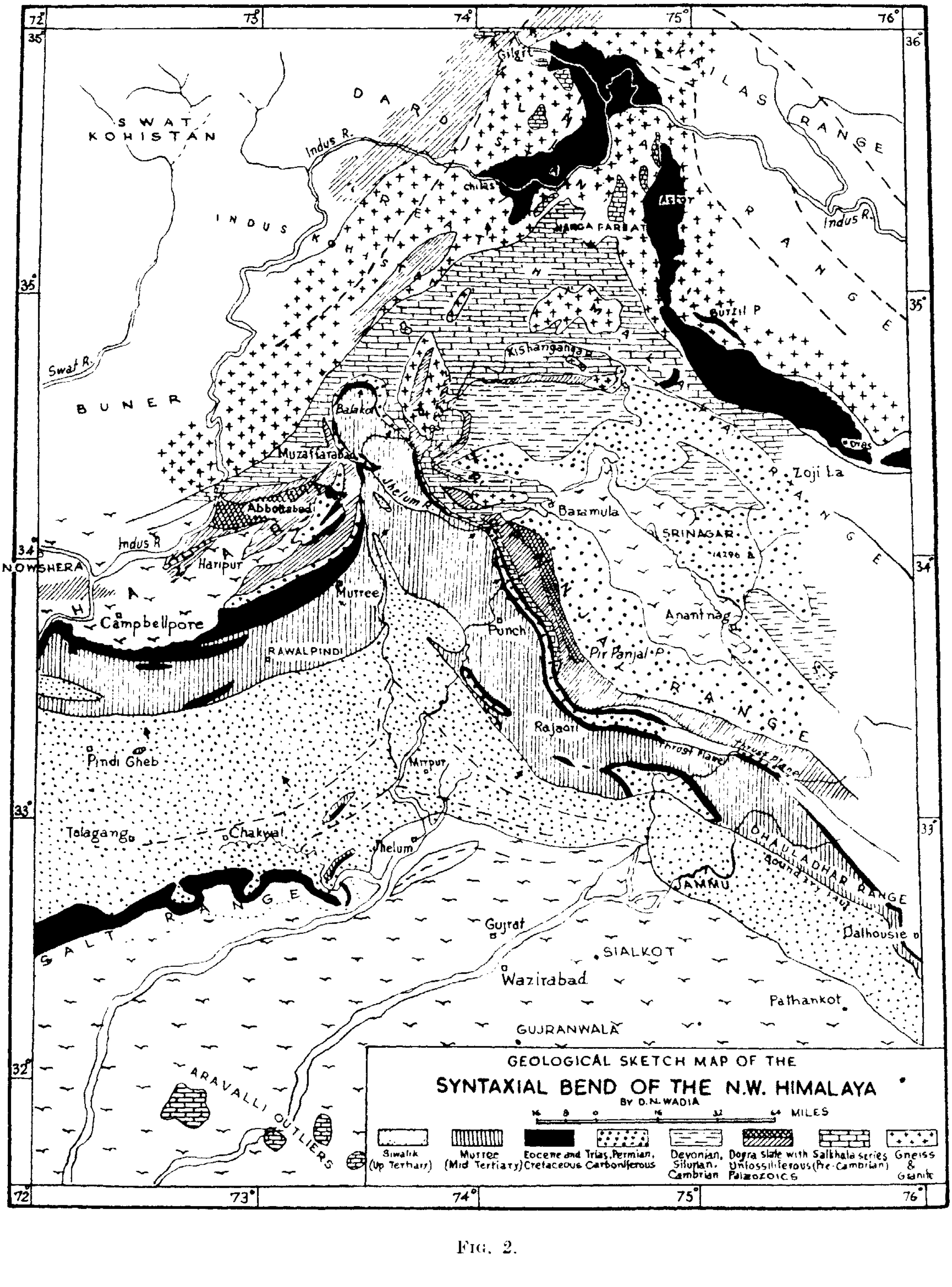
GEOLOGICAL SKETCH MAP OF THE
SYNTAXIAL BEND OF THE N.W. HIMALAYA
BY D.N. WADIA
MILES
Siwalik (Up Tertiary)
Murree (Mid Tertiary)
Eocene and Cretaceous
Trias, Permian, Carboniferous
Devonian, Silurian, Cambrian
Dogra slate with Unfossiliferous Palaeozoics
Salkhala series (Pre-Cambrian)
Gneiss & Granite
SWAT KOHISTAN
INDUS KOHISTAN
BUNER
Gilgit
Chilas
Indus R.
Swat R.
Balakot
Muzaffarabad
Abbottabad
Haripur
NOWSHERA
Campbellpore
Murree
RAWALPINDI
Punch
Rajaori
Pir Panjal P.
Baramula
SRINAGAR
Anantnag
Zoji La
Kishanganga R.
Jhelum R.
Pindi Gheb
Talagang
Chakwal
Mirpur
Jhelum
SALT RANGE
Gujrat
SIALKOT
Wazirabad
Pathankot
GUJRANWALA
JAMMU
Dalhousie
DHAULADHAR RANGE
Thrust Plane
ARAVALLI OUTLIERS
Indus R.
NANGA PARBAT

FIG. 2.

diastrophism, has built the youngest, highest and largest relief feature on the Crust of the Earth, profoundly affecting the gravity and isostatic adjustments of the Sub-Crust overlying the Upper Mantle. (The Andean chain of South America is far larger, extending over 4,500 miles from Columbia to the farther end of Chile; it is, however, not a single orogen, but a composite body, elevated at several distinct orographic periods, containing varied structures and types of sediments including large volcanic complexes).

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