World Geomorphological Landscapes

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Nizamettin Kazancı *Editors*

Landscapes and Landforms of Turkey

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Foreword

So far, only five books have been published describing the landscapes of Turkey as a whole (Tchiatcheff 1866a, b; Güldalı 1979; Kurter 1979; Atalay 1982, 2nd edition 1987; Erol 1983). Ardos (1979) is a most inadequate account of the geomorphology of Turkey from a neotectonic perspective only, and Eken et al.'s (2006) magnificently illustrated volumes deal almost exclusively with biogeography and ecology with minimal data on landforms. None of these books could satisfy either the professional or the general reader interested in the landforms of Turkey both in terms of the material presented and in the manner it is presented. The book in your hand is the first trying to fill the void of a geomorphological description of Turkey, but it addresses itself mainly to the educated public.

It seems surprising that so little has been written about the geomorphology of a piece of land that is located in the middle of the inhabited world since the inception of human history and along the western shores of which human civilisation was created by its Greek-speaking people. In fact, the famous American classicist William Arthur Heidel (1868–1941) said that Anaximander's book, the first prose text ever generated in Greek and supposedly called Περί Φύσεως (*peri phuseus:* on nature), was actually a book about geography (Heidel 1921) and it may have contained his famous map (Fig. 1). Geography developed continuously after the Presocratics and reached its apogee in the ancient world with the work of Claudius Ptolemy (c. CE 100–170), entitled Γεωγραφικὴ Ὑφήγησις (*Geographike Ufegesis*: guide to geography). However, Ptolemy's work was mathematical geography only and the associated cartography. The great general geographer of antiquity was Strabo (c. 64 BCE–c. 24 CE) a native of Amaseia (now Amasya, a town in Turkey). In his Γεωγραφικά (*Geography*), consisting of seventeen books, he left us wonderful descriptions of the physical geography of what is today Turkey in books XII and XIII.

Strabo divided Asia into two moieties by the transcontinental Taurus (II, 5, 31–32, and XI, 1), which, according to him, had a length of 45,000 stadia[1] from one end to the other (XI. 1. 3); he called the northern part Cis-Tauran and the southern part Trans-Tauran (Strabo, II. 5. 31 and XI. 1. 2). From Strabo's statement that "since Asia is divided in two by the Taurus range, which stretches from the capes of Pamphylia to the eastern sea at India and farther Scythia, the Greeks gave the name of Cis-Tauran to that part of the continent which looks towards the north, and the name of Trans-Tauran to that part which looks towards the south; it is clear that he did not invent these specific designations" (see also XI. 1. 2). He had certain disagreements with his predecessor Eratosthenes (c. 276–196 BCE), the man who had invented the term *geography*, as to which regions were Cis-Tauran and which Trans-Tauran,

[1]Here, Strabo uses the Eratosthenian stadia, i.e. 1 stade being considered here equivalent to 157.50 m. (1/250,000 of the length of the equator following Berthelot 1930). Thus, for 45,000 stadia, we obtain roughly 7000 km length for the Taurus (Berthelot 1930, p. 91). While the modern equivalent of the Greek stade is still a matter of much dispute today, it ranges from 185 to 148 m in the modern literature of the history of cartography. For literature, see Harley and Woodward (1987, p. 148, note 3).

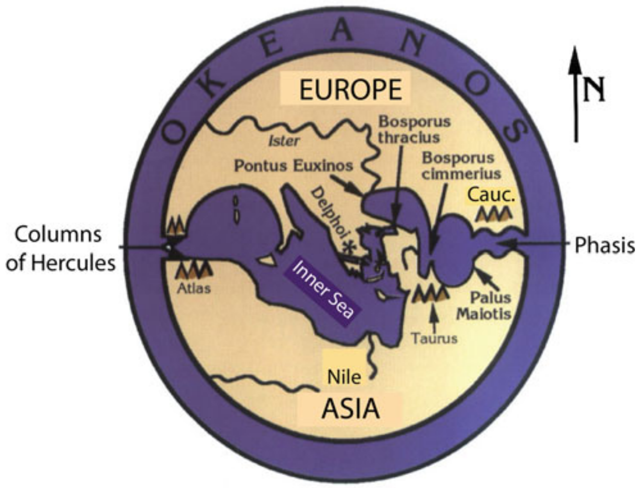

Fig. 1 Şengör's (2000) attempt at a reconstruction of Anaximander's world map (*pinax*)

because Strabo appreciated the breadth of the Taurus better than Eratosthenes had done (see, for example, Strabo, XI. 12. 5). This appreciation led him to the concept of a plateau, an *oropedia* (=mountain plain) as he expressed it, as opposed to just a range of mountains (Fig. 2).

According to Strabo, the Taurus begins where the Reşadiye Peninsula (*Rhodian Peraea*: identification after Kiepert 1878, p. 123) joins the mainland (Fig. 1). "From here the (mountain) ridge continues [*presumably westward and/or northward*], but it is much lower and is no longer regarded as part of the Taurus" (Strabo, XIV. 2.1). Both here and in a later place (Strabo, XIV, 3.8), Strabo combats the view that the Taurus mountains begin at the Hieran promontory (Identification after Jameson 1971, Fig. 1; Cape Kilidonya or Gelidonya or Kırlangıç or Yardımcı: Fig. 2). This view had supporters "not because of the loftiness of the promontory, and because it extends down from the Pisidian mountains that lie above Pamphylia, but also because of the islands that lie off it [*Chelidoniae*], presenting as they do, a sort of conspicuous sign in the sea, like the outskirts of a mountain" (Strabo, XIV, 3. 8). This island=mountain equivalence encourages me in thinking that both Strabo and his predecessors probably considered island genesis (i.e. uplift out of the sea) and mountain genesis as parts of the same process of uplift on Mediterranean examples.

Strabo knew that the Taurus, all along its length, does not form a singular ridge of mountains. He justifies his singling out of the Taurus to name the entire mountain system that traverses Asia from west to east as follows (a justification that may have been employed also by his predecessors Dicaearchus {c. BCE 350–285} and Eratosthenes): "…neither are the parts outside [*i.e. to the south of*] the Taurus and this side [*i.e. north*] of it so regarded, because of the fact that the eminences and depressions are scattered equally throughout the breadth and length of the whole country, and present nothing like a wall of partition [*as does the Taurus*]" (Strabo, XIV. 2. 1). In Caria and Lycia (present provinces of Aydın and Denizli and the western part of Muğla, and the eastern part of Muğla and western part of Antalya, respectively, in Turkey), the Taurus "has neither any considerable breadth nor height, but it first rises to a considerable height opposite the Chelidoniae … [*present Beşadalar or the Devecitaşı Islands*] and then stretching towards the east encloses long valleys, those in Cilicia [*present Karaman, İçel, and Adana*], and then on one side the Amanus Mountain splits off it and on the other the Antitaurus Mountain…. Now the Antitaurus ends in Cataonia [*present northern Kahramanmaraş*], whereas the mountain Amanus extends to the Euphrates river and Melitinê [*present*

Malatya][2]… And it is succeeded in turn by the mountains on the far side of the Euphrates, which are continuous with those aforementioned, except that they are cleft by the river [*i.e. Euphrates*] that flows through the midst of them. Here its [*i.e., of the Taurus*] height and breadth greatly increase and its branches are more numerous. At all events, the most southerly part is the Taurus proper, which separates Armenia [*i.e., east Anatolian high plateau*] from Mesopotamia [*i.e., roughly the Border Folds region in Ketin's 1966, sense; Assyrides of Şengör et al. 1982*]" (Strabo, XI, 12. 2) (Fig. 2). Then, Strabo assumes following Dicaearchus and Eratosthenes "that the Taurus extends in a straight line… as far as India" (Strabo, XIV, 5.11). "It is said that the last part of the Taurus, which is called Imaïus and borders on the Indian Sea, neither extends eastwards farther than India nor into it" (Strabo, XI. 11. 7).

As von Humboldt (1843, p. 58, note 1) pointed out, it was Strabo's important contribution to have distinguished "mountains" from "plateaux": for the latter, he introduced the technical term *oropedia*.[3] He noted that Eratosthenes' Taurus System "has in many places as great a breadth as three thousand stadia"[4] (Strabo, XI. 1. 3). He also knew that "the Taurus has numerous branches toward the north" (Strabo, XI. 12. 4), which he described under the names Antitaurus (XI. 12. 4), Scydises (XI. 2. 15), Moschici (XI. 2. 4) and Pariadres (XII. 3. 18; some topographic details at XII. 3. 28). East of these, he noted a number of parallel chains in the present-day eastern Turkey, which, according to Strabo, "comprise many mountains [*ore*], many plateaux [*oropedia*]" (XI. 12. 4), all of which comprising the main trunk of the Taurus System of Eratosthenes here (Fig. 2).

Farther west, Strabo names a number of mountains roughly along the strike of the Paryadres (Lithrus and Ophlimus: XII. 3. 40; farther west Arganthonius and Olympus: XII. 4. 3, and finally Ida: XII. 8. 8; on the Kapıdağ Peninsula, Dindymus: XII. 8. 11; Fig. 5) that define an independent train north of the dry interior plains of central Anatolia (Strabo's "waterless plateaux of Lycaonia": XII. 6. 1). All of these ranges are considered a part of the Taurus and not parts of an independent chain, probably on account of their connexion with the Paryadres in the east and their inferior hypsometry compared with the main Taurus range in the south. Although Strabo talks about the "sacred mountain" Hieros (present Ganosdağ; formerly Tekfur Dağı; now changed to Işıklar Dağı) in Thrace, he makes no connexion between the Thracian mountains and those of northern Anatolia. This is probably because the main mountain range just north and west of Thrace, the Haemus (the Balkan), runs out to the sea (Strabo, VII, 6. 1) and because Strabo thought that the Taurus was confined to Asia.

Strabo describes at length the waterless plateaux of Lycaonia as "cold, bare of trees, and grazed by wild asses" (XII. 6. 1), and here, he clearly recognises a distinctive landform contrasting with the mountains to the south and to the north, for which he again employs the term *oropedia*. This *oropedia* of Lycaonia is bordered on the south by the *Taurus proper* (Strabo, XII, 6. 1), yet it is enclosed within the *Taurus System* (Fig. 2). In the description of the Taurus in Asia Minor, we note that Strabo recognised the branching out of a mountain stem, the various branches enclosing plateaux (e.g. XI. 2. 15; XII, 2. 2), thus first indicating what

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[2]We know now that Amanos really ends at a tributary called Aksu of the Ceyhan just to the south of the town of Kahramanmaraş, and the ranges grouped under the designation Antitaurus reach much farther north and east than the ancient Cataonia, even on the basis of Strabo's own data.

[3]In two manuscripts of the Hippocratic treatise Περί αέρων, υδάτων, τόπων (=*Airs, Waters, Places*), namely in the *Codex Vaticanus Graecus* 276 (twelfth century AD) and *Codex Barberinus* (fifteenth century AD), we read in paragraph XVIII, "ή δὲ Σκυθέων ἐρημίη καλευμένη πεδιάς ἐστι καὶ λειμακώδης καὶ ὑψηλὴ καὶ ἔνυδροσ πετρίως" instead of "ή δὲ Σκυθέων ἐρημίη καλευμένη πεδιάς ἐστι καὶ λειμακώδης καὶ ψιλὴ καὶ ἔνυδροσ πετρίως" (see Jones 1923 [1984], p. 118). Jones (1923 [1984], pp. 118 and 119) translates "ὑψηλὴ" as "plateau". Thus, the first sentence would read in English "What is called the Scythian desert is level grassland, a plateau (ὑψηλὴ), and fairly well-watered," whereas the second, Jones' preferred reading, "What is called the Scythian desert is level grassland, without trees (ὴ bare), and fairly well-watered". If the ὑψηλὴ reading is correct, as it appears in most manuscripts, then the *concept* of a plateau as a highland would have to be dated some five centuries before Strabo, but even in that case we do not see a special technical term. The introduction of a *special term* to express the concept of a plateau in all cases belongs to Strabo.

[4]I.e. 472 km width!

was to be called later virgations by von Humboldt, Ritter and Suess (Fig. 2), a concept that was to play a critical rôle in the tectonic interpretation of all Asiatic mountain ranges.

East of Asia Minor, the Taurus continues in the present Transcaucasia (Armenia and Azerbaijan) and northern Iran as the Parachoathras Mountains (in Strabo's terms from Armenia to the east of the Hyrcanian Sea, i.e. the present Caspian Sea) and he points out that they continue in a straight line from Cilicia in Asia Minor (Strabo, XI. 8. 1). Farther south, he recognised in the eastern Anatolian high plateau another branch, the so-called Gordyaean Mountains (mountains of Cordyene, i.e. of Kurds, as first noticed by the English historian and theologian George Rawlinson (1817–1902), the younger brother of Sir Henry Creswicke Rawlinson (1810–1895), the founder of Assyriology, in the nineteenth century: Rawlinson undated [1876?], p. 308), including the Mt. Masius[5] (not to be confused with Mt. Masis in Armenian, which is a volcanic cone much farther north: Mt. Ağrı, inappropriately known as Mt. Ararat[6]), which eventually joined with the Zagros in Iran (Strabo, XI. 12. 4).

In Strabo's account, we thus recognise a rather large number of mountain ranges, high plateaux surrounded by them and coastal plains along the course of "Dicaearchus and Eratosthenes" Taurus. Strabo thought that most of the mountain ranges he wrote about, extended east-west although he knew of important exceptions such as the Anti-Taurus and the Amanus. All of these he considered a part of the east–west trending Taurus System, although he often made a distinction between the *Taurus System* and the *Taurus proper*. Farther east, still Strabo's knowledge becomes less comprehensive: "Now the Macedonians gave the name Caucasus to all the mountains which follow in order after the country of the Arians[7]; but among the barbarians the extremities on the north were given the separate names Paropamisus and Emoda and Imaus; and other such names were applied to separate parts." (Strabo, XI, 8. 1[8]).

Unfortunately, Strabo offers little in terms of an interpretation of the origin of these mountains and the various structures he distinguishes within them.[9] He does describe, however, the earthquakes, hot springs,[10] the former volcanic activity and the associated changes in the landscape in western Turkey, for example (Strabo, XII. 8. 17, 18, 19), and in connexion with what he says on the overall tectonic phenomena known to him, in the first two books of his *Geography*, there is little reason to think that his tectonic views differed considerably from those of Eratosthenes. We are thus led to think that Strabo too considered the Taurus a product of vertical uplift associated with plutonic forces. He believed in a non-uniformitarian, in fact

[5]These are what today we call the south-eastern Taurus Mountains in south-eastern Turkey that delimit the Tethyside orogenic belt against the Arabian platform. The designation south-eastern Taurus occurs in *The Times Atlas of the World*, twelfth comprehensive edition, 2007, directly in Turkish as *Güney Doğu Toroslar*. In the *Brockhaus Enzyklopädi*e (19th edition) *Weltatlas*, they are named the *Äußerer Osttaurus* (Outer East Taurus). The main authority for the toponym south-eastern Taurus is the *Yeni Türkiye Atlası* (Ankara 1977) published by the Cartographic Command of the Turkish Army.

[6]Genesis VIII, 4; in fact, the whole of eastern Turkey may have been meant by "Ararat"=Urartu: for this tradition, see Jackson and Morgan (1990, p. 267, note 1).

[7]Present-day Iran and Turkmenia plus northern Afghanistan.

[8]Berthelot (1930, p. 92) quotes this passage from Strabo, but before the Paropamisus he lists an Agriens mountain. In the two Strabo translations I have at hand writing this article (Hamilton and Falconer in the Bohn's Classical Library 1856, v. II; and Jones in the Loeb Classical Library 1969, *The Geography of Strabo*, v. V), these mountains are not mentioned, as neither also in the Loeb Greek text in any form. The same is true in the new Strabo edition and translation by Radt (2004, pp. 340–341). I thus do not know from what source Berthelot derived the name Agriens.

[9]One can hardly blame Strabo for this, because his intent was to write a historical and political geography as an outgrowth of his earlier historical studies and travels, which he hoped would be of use to the rulers of his country (i.e. to Pythodoris, the Queen of Pontus, and not to the Romans: Jones 1917, pp. xxv–xxvi).

[10]In Hierapolis (present Pamukkale), Strabo mentions the famous white travertine deposits as "plutonium", i.e. as products of Pluto, the god of the netherworld (XIII. 4. 14). He clearly makes a connexion between the "plutonia" and volcanic phenomena, because he also calls "plutonium" the "vapours" (fumaroles, here the type locality of Solfatara!) rising in the Phlegraean Fields (or Phlegraean Plain: Campi Flegrei, volcanic region west of Naples and east of Cumae) in Italy, an active volcanic province containing some 19 low craters, the last of which, appositely called Monte Nuovo, was formed as late as 1538 AD (cf. Scrope 1862, pp. 319ff. and fig. 60 on p. 232; Bullard 1980, p. 187). This volcanic district was recognised by Strabo as such (Strabo, V. 4. 5).

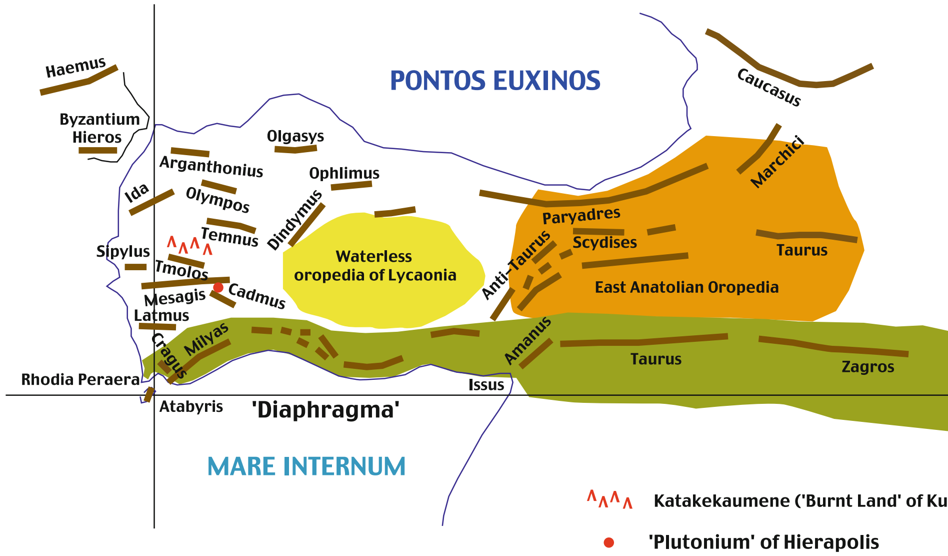

Fig. 2 Strabo's view of the geomorphology of Turkey as reconstructed by Şengör (in Şengör et al. 2008)

catastrophic behaviour of nature,[11] but one that displayed a great regularity of behaviour. Von Humbolt (1843, pp. 132–133) finds this confidence in regularity expressed in the straight course ascribed by Eartosthenes and Strabo to the Taurus System that supposedly unerringly followed the 36th parallel. Von Humboldt searches the source of this confidence in a "certain predilection for the regularity of forms" and thus underlines the influence of Plato and Aristotle on our geographers (Fig. 2).

Although Rome was already in intellectual decline (Strabo was only followed within the same century by the Spaniard Pomponius Mela {died 45 CE} with his *De situ orbis libri III*, which is an incomparably poorer performance), the rise of Christianity and the gradual decline

[11]In his first book, Strabo wrote: "… but such changes as Eratosthenes mentions do not in any particular alter the earth as a whole (changes so insignificant are lost in great bodies) though they do produce conditions in the inhabited world that are different at one time from what they are at another, while *the immediate causes which produce them are different at different times*" (Strabo, I. 3. 3; italics are mine). I interpret this as a non-uniformitarian statement, for Strabo later on (II. 3. 6) applauds Posidonius for thinking that the story about the disappearance of Atlantis (in a single day and night: Plato, *Timaeus*, 25; especially Taylor 1928 (1972), p. 56, where Taylor stresses that "The earthquake and the deluge are the constituents of one sudden convulsion of nature". See his entire discussion there under the entry 25c6) is not a fiction. Kidd (1988, p. 259), in his commentary on this passage of Posidonius quoted by Strabo, rightly expressed some surprise at Strabo's credulity in this particular case, for he is much more conservative in general. His credulity here can only be explained, I think, by the conformity of Plato's catastrophism to his own views.

Lyell, in all editions of his *Principles of Geology* (Lyell 1830, 1875), makes Strabo an uniformitarianist, because of Strabo's criticism of Strato and Eratosthenes. But Lyell (e.g. Lyell 1830, p. 19) paraphrases the great geographer out of context. Strabo, in his criticism, is made by Lyell to say that "It is proper to derive our explanations from things which are obvious, and in some measure of daily occurrence, such as deluges, earthquakes, volcanic eruptions, and sudden swellings of the land beneath the sea". This is also how Ellenberger (1988, p. 26; also see the third motto on p. 11) reads him. The very literal translation of Jones (1917, v. I, p. 199) reads, however, as follows: "…it is necessary for me to bring my discussion into closer connexion with things that are more apparent to the senses and that, so to speak, are seen every day. Now deluges; and earthquakes, volcanic eruptions, and upheavals of the submarine ground raise the sea, whereas the settling of the bed of the sea lowers the sea. *For it cannot be that burning masses may be raised aloft, and small islands, but not large islands; nor yet that islands may thus appear, but not continents*" (my italics). The sentence I italicised, when considered in connexion with Strabo's views on the Atlantis, constitutes an attack on uniformitarianism, not an argument in its favour. Strabo was defending a common-sense catastrophism without resorting to fabulous causes. Ellenberger (1988, p. 26) considers Strabo an uniformitarianist–moderate catastrophist. I would agree with this judgement provided emphasis is placed on the word catastrophist in Cuvier's sense.

and eventual collapse of the Roman Empire dealt a severe blow to human civilisation and very adversely affected the people living in what is present-day Turkey. Two structures perhaps best characterise the frame of mind that reigned from the time of St. Basil the Great (330–379), the bishop of Caesarea Mazaca in Cappadocia, to the end of the Ottoman Empire in the early twentieth century: the rock-cut dwellings and temples of Cappadocia and the Topkapı Palace in İstanbul. Both are turned away from the grand landscapes surrounding them and imprisoned their dwellers in human imagination enslaved by primitive myths. Geography of any kind made essentially no progress in Turkey beyond what the Greeks of antiquity had left well into the time of the great geographical discoveries following and paralleling the later phases of the Renaissance. A few bright spots represented by such individuals as Maximos Planudes (c. 1260–1305), Ahmed Muhiddin Pirî Reis (c. 1465/70—1553), Mustafa bin Abdullah, known as Kâtip Çelebi or Haji Khalifa (1609–1657) and Mehmed Zilli known as Evliya Çelebi (1611–1682) could not illuminate the dark centuries in geography and the sciences in general represented by the duration of the Eastern Roman and the Ottoman empires. It is surprising that the Muslim Ottomans did not even benefit from the great Muslim heritage in geography.

An awakening interest in the earth sciences concerning the area of Turkey began with the onset of scientific travelling in the lands of the Ottoman Empire by Europeans beginning mainly in the eighteenth century and greatly accelerating during the nineteenth century (e.g. von Hammer 1830; von Hammer-Purgstall 1844; Weber 1952, 1953; Tayanç 1972a, b; Brentjes 2002). Until the twentieth century, the Ottomans themselves took very little interest in such travels with a few exceptions such as the painter and archaeologist Osman Hamdi (1842–1910) who followed, and himself undertook, archaeological field studies. When the Ottomans travelled, the purpose was almost never scientific (see Coşkun 2002; Ak 2006).

The great geographer Carl Ritter (1779–1859) was the first who attempted a synthesis of the meagre information then available concerning the landforms of Turkey (Ritter 1858, 1859). Although, following Strabo, he held on to the idea that all the mountain ranges of Anatolia (his *Klein-Asien*) belonged to a single Taurus System (Ritter 1858, p. 27), he clearly distinguished two independent trains of coastal ranges of the Taurus, which he named:

(1) the Pontic–Bithynian Mountain System in the north and
(2) the Cilician–Lycian Taurus System in the south.

Ritter indicated, exactly as Strabo had done before him, that the two coastal ranges were separated by a high plateau country (Strabo's Lycaonian *oropedia*: Ritter 1858, p. 19). Ritter delimited Asia Minor against the bulk of Asia by means of the Anti-Taurus (which he terminated at the Hınzırdağ; Ritter 1858, p. 16) and pointed out that farther east the mountains showed a more massive rather than linear character that really looked like a high tableland (Ritter 1858, p. 37).

By contrast, the area of western Anatolia, Ritter noted, was characterised by an east–west lineated fabric where many small mountain ridges alternated with broad valleys. This, he thought, represented a failed attempt by the plutonic forces at plateau building (Ritter 1858, pp. 40–41). His two countrymen were to interpret that pattern half a century later in two contrasting manners: Alfred Philippson (1864–1953) as due to normal faulting and rift building (Philippson 1918); Walther Penck (1888–1923) as due to crustal folding (Penck 1918: *Großfaltung*), of which the former eventually prevailed.

I think that Ritter was the first to view the east-to-west decline of the regional elevation in Turkey as a consequence of tectonics, which he interpreted to be a result of plutonic forces that supposedly had become weaker westwards. In the east Anatolian high plateau, Ritter thought he was witnessing the full force of the uplifting agencies. This weakened westwards, but was still sufficient to create the two coastal ranges and the high central Anatolian plains. In the west, the plutonic forces were able to create only some low, parallel axes of uplift, but no well-defined mountain range, much less a high plateau.

These three main regions were connected by transitional areas. William John Hamilton's (1805–1867) and Prince Piotr Alexandrovich Tchichatcheff's (1808–1890) observations were available to Ritter, and he seems to have been impressed with their observations on the "diagonal ranges" in Anatolia (see Tchichatcheff 1887, for a convenient summary of his observations; see Ritter 1858, p. 42, note 18 for reference to Hamilton), which, Ritter noted, characterised his "transitional regions" (Fig. 12). This divergence from the "normal" east–west trends "is similar to the divergence of the Anti-Taurus in east Asia where through the transition zone from high mountains to high plains there occurs a divergence towards the southwest from normal parallel ranges, so here in west Asia in the transition zone from the compact high plains to the area differentiated into east-west elements, there occurs a divergence towards the north-west" (Ritter 1858, p. 42).

Following Pliny the Elder (23–79 CE), Ritter thought that the mountain systems of Anatolia continued across the Dardanelles and the Bosphorus into the European ranges. This continuation, however, was accompanied supposedly by a further weakening in the intensity of tectonism, so that neither plateaux of east Anatolian type nor high plains of central Anatolian type occurred in Europe (Ritter 1858, pp. 40–41).

With his incredibly perceptive views on the tectonics of Anatolia, Carl Ritter bequeathed to us a number of concepts that became a part of nearly all morphological and tectonic classifications of Turkey after him. These may be summarised as follows:

1. He emphasised the existence of two mountain systems that parallel the Black Sea and the Mediterranean coasts of Asia Minor, although he followed the old tradition, coming from Strabo, of considering them as parts of a united Taurus System.
2. He pointed out that the high plateau of eastern Turkey resulted from the fusion and enlargement of these two strands.
3. He showed that the mountain ranges of Asia Minor continued into the Balkan Peninsula across the Aegean Sea and the two straits of the Bosphorus and the Dardanelles.
4. He noticed the tectonic independence of western, central and eastern Turkey, which he ascribed to a decreasing degree of tectonism from east to west (owing to a parallel weakening of the causative plutonic forces, Ritter thought, in the framework of Élie de Beaumont's theory of tectonism).

For all his perceptiveness, Ritter remained committed to the dominant east–west trend of the Taurus System and the overwhelming parallelism of its various branches in Turkey, forming the northern and the southern coastal ranges.

Although when he wrote his volumes on Asia Minor (Ritter 1858, 1859), he knew about it only a little more than Strabo had known, and by the second half of the century it had become possible to draw a geological map of Anatolia (de Tchihatcheff 1869) and offer a classification of its tectonic units (Naumann 1896). The first volume of Prince Tchitchaff's monumental *Asie Mineure* was in fact the first physical geography book ever written on Anatolia (Tchihatcheff 1866a, b). All of this work was done by foreigners from Europe and the USA with not one contribution from the natives. The Austrian political refugee from the 1848 revolution Karl Eduard Hammerschmidt (1800–1874) came to Turkey became Muslim for political reasons and changed his name to Abdullah. Under his new name, he lectured on geology in the Imperial Medical School (*Mekteb-i Tıbbiye-i Şahane*), published on the geology of Istanbul and the areas around it and amassed a great collection of fossils (some 10,000 pieces! See Montero 1998), which were destroyed during the 1918 fire in the Geological Institute of the University of Istanbul. Abdullah was the first permanent resident of Turkey to publish on the geomorphology of the country describing the Yarımburgaz karstic cave west of Istanbul (Abdullah Bey 1869). He had no immediate successors among the natives of his adopted country until the twentieth century.

The faculty members of both the University of Istanbul (founded in 1900 under the name *Darülfünun*) and the old Imperial School of Engineering (*Mühendishâne-i Hümâyun* founded 1773; after 1909 *Mühendis Mekteb-i Âlisi*) undertook geological teaching and some local research in the 1920's. A Geographical Institute, founded by Karl August Erich Obst (1886–1981) in the University of Istanbul, proved less active in research.

The founding of the Republic of Turkey breathed new life into scientific activity in the country, neglected and indeed stifled for centuries. Both geology and geography greatly benefitted, and systematic research began with the invitation of the French geologist Ernst Chaput (1882–1943) in 1928 to the University of Istanbul. Chaput undertook extensive excursions in Anatolia with İbrahim Hakkı Akyol (1888–1950; professor of geography) and Hamit Nafiz Pamir (1893–1976; professor of geology) as his habitual companions. His great book *Voyages d'Études Géologiques et Géomorphogèniques en Turquie*, published in 1936 and translated into Turkish by Ali Tanoğlu in 1947, is really the first modern description of the geology and very especially geomorphology of the country in the twentieth century. Before Chaput, the only reconnaissance geomorphology done in Turkey was that by the great Serbian geographer Jovan Cvijić (1865–1927) in the surroundings of Istanbul and along the southern rim of the Sea of Marmara in two excursions in 1899 and 1905 (Cvijić 1908) and later by Alfred Philippson and Walther Penck in western Turkey. When Frédéric Dubois de Montpéreux (1798–1850) and Otto Wilhelm Hermann Abich (1806–1886) had worked in eastern Turkey (Dubois de Montpéreux 1839a–c, 1840, 1843a–e; Abich 1882), geomorphology had not yet advanced far enough to supply useful observations to the future generation of geographers and geologists except in regard to volcanic landforms. What is remarkable is that Dubois already shows volcanic flow directions around Mt. Ağrı and Mt. Sirak to the west of Ağrı. He also mapped *cendres volcaniques*, *trass and lapillis*! It was this richness in volcanic products and the detail in which Dubois was able to show them that in part attracted Abich, who had been enthused by Alexander von Humboldt's work on the volcanic regions of Latin America, to work in eastern Turkey.

Two developments occurred in 1933 and 1935 in Turkey: one with unfortunate and the other with beneficial consequences for the development of geology and geography in Turkey. The first one occurred in 1933 when the *Darülfunun* was closed and the new University of Istanbul was opened with a new organisation. During that reorganisation of the higher education in Turkey, the Turkish geographers decided to follow the French model and placed themselves into the Faculty of Letters instead of into the Faculty of Science (Akyol 1943; Darkot 1951; Erinç 1973). This had devastating consequences for the development of geography in Turkey in the long run, which dwindled into almost total insignificance as a branch of higher learning and research by the end of the twentieth century (see İzbırak 1976, Hütteroth 1992; Erinç 1997, for the later developments till 1997). Özey (1998) and Kayan (2000) review the development of geographical education in the Turkish universities till the end of the first millennium reflecting its gradual deterioration. The decline of geography in Turkey was felt so acutely that the Turkish Industrialists' and Businessmen's Association (=*Türkiye Sanayicileri ve İş Adamları Derneği*: TÜSİAD) felt that it had to intervene and made a misguided effort to have a model high-school text written (see Pérouse 2005).

The second, but this time beneficial, development was the founding in 1935 of the geological survey of Turkey under the name *Maden Tetkik ve Arama Enstitüsü* (Institute of Mineral Research and Exploration of Turkey: see Acun 1947; Anonymous 1956, 2010). This organisation (turned into a General Directorate to curtail its independence for short-sighted political reasons in 1984) gave an immense impetus to geological mapping and research and provided employment not only for Turkish geologists but also for geomorphologists coming from a geographical background. As geography declined in universities, the geomorphologists of this institute (later General Directorate) carried on the geomorphological research in the country. Gradually, as geomorphology became increasingly more technology-dependent and quantitative, more and more geomorphology in Turkey has shifted into geology departments and institutes and, as the majority of the papers in the present volume testify, it is they that now undertake by far the greatest portion of modern geomorphological research in Turkey. Topographical mapping in Turkey remains largely in the hands of the Turkish Army (Anonymous 1959, 1962, undated [1993?]) and marine bathymetric mapping in the hands of the Office of Navigation, Hydrography and Oceanography of the Turkish Navy (Anonymous [Barkınay, A. H.] 1932). Both organisations have been producing superb maps.

The following bibliographies are useful to obtain an overview of the development of geomorphological research and teaching in Turkey: Trak (1942), Mansel (1948 (1993)), Ödekan (1975), Brinkmann (1981, 1984), Doğu (1981, 1988), Erol (1984), Sözer (1974), Nazik (1985), Coşkun and Özbek (1986), Hakyemez (1991), Doğaner (1992), Ulu (1992), Tunçel (1994) İhsanoğlu et al. (2000), Bayrak (2001), Tunçel et al. (2010).

The present volume is the first modern synthesis of the geomorphology of Turkey after the rise of plate tectonics and the revolution in our understanding of the dependence of the climate on orbital parameters and atmospheric composition. It is also the first after computers and the GPS. Its editors have undertaken a herculean task in gathering the authors and editing the manuscripts both scientifically and linguistically—a task much more difficult in Turkey than in scientifically more advanced countries. Few in more fortunate circumstances can appreciate the massive hindrances in front of doing and organising science in places where there has been no scientific tradition. That is why not only the readers of this book, but also all those hoping to do and to improve science in Turkey will be forever in the debt of the editors of the present book not only for what they provide, but also for their example.

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Series Editor Preface

Landforms and landscapes vary enormously across the earth, from high mountains to endless plains. At a smaller scale, nature often surprises us creating shapes, which look improbable. Many physical landscapes are so immensely beautiful that they received the highest possible recognition—they hold the status of World Heritage properties. Apart from often being immensely scenic, landscapes tell stories which not uncommonly can be traced back in time for tens of million years and include unique events. In addition, many landscapes owe their appearance and harmony not solely to the natural forces. For centuries, and even millennia, they have been shaped by humans who have modified hillslopes, river courses and coastlines, and erected structures, which often blend with the natural landforms to form inseparable entities.

These landscapes are studied by geomorphology—"the science of scenery"—a part of earth sciences that focuses on landforms, their assemblages, surface and subsurface processes that moulded them in the past and that change them today. To show the importance of geomorphology in understanding the landscape, and to present the beauty and diversity of the geomorphological sceneries across the world, we have launched a book series *World Geomorphological Landscapes*. It aims to be a scientific library of monographs that present and explain physical landscapes, focusing on both representative and uniquely spectacular examples. Each book will contain details on geomorphology of a particular country or a geographically coherent region. This volume presents the geomorphology of Turkey, a large country blessed with a multitude of extraordinary landscapes, from the world-famous "fairy chimneys" of Cappadocia and travertine terraces of Pamukkale—appreciated by an ever-increasing number of tourists every year—to many hidden gems scattered across the Anatolian Plateau, the Pontides and the Taurus. Whatever your specific interests in geomorphology, you will not be disappointed. Turkey is a perfect candidate for a geomorphology textbook, having it all: tectonic landforms at all scales, volcanoes and lava plateaus, amazing karst, deep fluvial gorges, badlands, legacy of mountain glaciation, spectacular coastal scenery and impressive testimony of human interference with natural processes. But this book goes beyond simply showing the scenery. It helps to read and understand the landscape, unravelling millions of years of history of landform evolution controlled by the movement of tectonic plates and climate change in one of the global geodiversity hotspots.

The World Geomorphological Landscapes series is produced under the scientific patronage of the International Association of Geomorphologists (IAG)—a society that brings together geomorphologists from all around the world. IAG was established in 1989 and is an independent scientific association affiliated with the International Geographical Union (IGU) and the International Union of Geological Sciences (IUGS). Among its main aims are to promote geomorphology and to foster dissemination of geomorphological knowledge. I believe that this lavishly illustrated series, which sticks to the scientific rigour, is the most appropriate means to fulfil these aims and to serve the geoscientific community. To this end, my great thanks go to the editors of this volume—Profs. Catherine Kuzucuoğlu, Attila Çiner and Nizamettin Kazancı—who launched this massive and time-consuming project and made every effort to deliver a high-quality final product. I am sure they see the result of their hard work as rewarding. Turkey did not have a book about its geomorphological richness in English before, and now, this impressive natural legacy can be enjoyed by the global geomorphological community. I am also grateful to all individual contributors who agreed to add the task of writing chapters to their busy agendas and delivered high-quality final products.

Piotr Migoń

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Editors and Contributors

About the Editors

Catherine Kuzucuoğlu is *Directrice de Recherche* at the Centre National for Scientific Research (CNRS). Geomorphologist, she works in the fields of physical geography, geoarchaeology and Quaternary climate/environments/volcanism. She is a member of the *Laboratoire de Géographie Physique* at Meudon (LGP, UMR 8591 of the CNRS, Universities of Paris 1 Panthéon-Sorbonne and Paris 12 U-Pec). After a Ph.D. thesis (1980) performed in Turkey under the directions of Profs. R. Coque (Paris 1) and O. Erol (Istanbul University) and the support of Directorate of Mineral Research and Exploration (MTA), she has developed several research programmes within French–Turkish collaboration projects with MTA, the Scientific and Technological Research Council of Turkey (TÜBİTAK) and various Turkish universities. The topics she specialised in are (1) the recent geomorphologic evolution of river terraces, (2) the geomorphological impacts of volcanoes on landscapes and on past human societies, (3) the reconstructions of climate and environment since the LGM and their impacts on past civilisations (using lake and marsh records). Her researches concentrate in central Anatolia from Beyşehir/Konya to Cappadocia (in its largest territorial meaning), also developing towards Mediterranean Anatolia and Eastern Anatolia. She has been the Deputy Director in charge of Archaeology at IFEA in Istanbul (French Institute for Anatolian Studies: 2000–2003) and the Director of the Laboratory of Physical Geography (2009–2013).

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