# The Ankara Melange and the Anatolian Thrust

By

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One of us (W. J. M.) was professor of Geology in the University of Ankara from 1944 to 1949. During this period opportunities were taken of exploring many parts of Turkey. Welcome financial assistance was received from the Royal Society through the British Council; while invaluable geological guidance was obtained from the findings of previous workers (e.g. Chaput 1930-1936). Fortunately, a very useful summary of these findings is available in the eight sheets of the Turkish Geological Survey of the country 1:800,000, issued 1941-1946 by the Maden Tetkik. ve Arama Enstitüsü (Institute of Mining-Study and Research), which corresponds roughly with the Department of Scientific and Industrial Research in Britain

One result has already appeared, namely announcement of the widespread occurence of pillow lavas (McCallien 1950). Apparently the name pillow lavas has not previously been employed for Turkish examples, though some of them are among the clearest in the world. In many cases these lavas occur with serpentine and radiolarian cherts in what is known as the green-rock or ophiolite association. Thus the recognition of pillow lavas completes for Turkey the Steinmann trinity, pillow lava, serpentine, radiolarite. Steinmann's realisation of this trinity, as a world-wide, age-long characteristic of geosynclinal deposition ranks, among the most exciting achievements of geological research (cf. Bailey 1936, p. 1718). The pillow lavas of Turkey are decomposed basic rocks, of the general type called spilite by Flett and others in Britain. Another feature of Turkish Geology, well illustrated in the Ankara district along with Steinmann's trinity, is the broken, block condition of pre-Tertiary rocks, holding as a general feature over an extremely wide area. The resultant complication is so great that it was decided, if possible, to arrange a joint excursion to investigate the phenomenon in considerable detail. The adventure has materialised through the generous backing of the Carnegie Trust, the University College of the Gold Coast, and the M. T. A. Enstitüsü. The two former delivered us at Ankara, where to our delight we found ourselves enrolled as temporary members of the Turkish Geological Survey.

We worked for rather more than a month from two centers, the modern Turkish capital, Ankara, and the ancient Hittite site, Alaca Höyük, excavated by the Turkish Historical Society since 1935, Alaca Höyük lies a dozen kilo-

meters WNW of the town of Alaca and 160 kms. ENE of Ankara. Our facilities included Jeep transport, which took us «over hill, over dale» to «wander everywhere», like Puck in Shakespeare's fairy tale. What we saw of the broken rocks, consisting mainly of greywackes, limestones, and the Steinmann trinity, rivalled in abandoned disarray Puck's most mischievous attempts to puzzle and confuse mere mortal man. Yet, with the help of fossils, mostly of the micro-order, and found quite commonly both in the limestones and the cherts, the Geological Survey map has diagrammatically divided the area into Paleozoic and Mesozoic, with local refinements such as Permo - Carboniferous, Lias, Oolite and Jurasso-Cretaceous. We established undoubted, important recurrences of rock types at more than one horizon; but broadly speaking we are satisfied that the main greywackes are Devonian, the main limestones, Permo - Carboniferous in an inclusive sense, and the main developments of Steinmann's trinity, Mesozoic. It had been impossible for the professor himself to undertake detailed mapping, since, quite properly under existing conditions, a foreigner attempting such a task is subjected to endless questioning. On the other hand, a research student, Oğuz Erol, starting in 1947 and working under close supervision, produced a valuable thesis the title of which when translated reads «A Study of the Geology and Geomorphology of the Region S. E. of Ankara in Elmadağ and its Surroundings»; and this is illustrated with a careful geological map (not as yet published) on the scale of 1: 100,000. For our present purpose it is only necessary to say that Erol firmly established a broken block structure for the greywacke-limestone complex of the wide district he described, in many cases separating individual blocks of limestone on his map; and that he found numerous microfossils in limestones, some of which have been referred by paleontologists to the Middle Permian. We had the great advantage of Erol's company and guidance during one, week of our visit.

It is thought that it may be helpful to furnish a preliminary note on our results, as they bear closely upon current discussions of such topics as the Simme Nappe of the Alps, the Ligurian Nappe of the Appennines, and the Radiolarite Nappe of the Zagros Mountains in Iran.

(1) Ankara is situated upon exposures of pre-Tertiary rocks obscured to some extent by Neogene cover. These exposures, rimmed by Eocene or Oligocene, are due to what may be called the Ankara Anticlinal, and run in a general North-Easterly direction continuing thus to the foot of the Pontic (Black Sea) Mountains past Çankırı, the latter 100 km, NE of the Capital. Our personal knowledge of the exposures extends from near Haymana, 60 km. SW of Ankara, to about half way between Ankara and Çankırı. The width of the belt at Ankara is about km. In all parts of this anticlinal country, which we have seen, the pre-Tertiary rocks, are in the condition of a melange, with the possible exception of some of the greywacke, which, however, only give poor exposures. We definitely know from our own experience, of some 6000 sq. km. of melange as exposed along the Ankara anticlinal, and it is clear that this is only a small fraction of an immense whole. For instance, Blumenthai in a map showing part of the pre-Tertiary

beyond Çankırı reserves a tablet for «Mesozoique a facies tectonique brouille» (1948, Fig. 2; see also below under heading 4). We propose to call this broken, mixed zone the Ankara melange, but of respect for the description E. Greenly and C. A. Matley have given of the somewhat similar Owna melange in Anglesey and the adjoining Lleyn peninsula of Wales (cf. Greenly 1919).

(2) The Ankara melange is composed of fragments and masses of the component rocks already cited, ranging exceptionally up to kilometres in length. The most widespread and conspicuous blocks are made of white-weathering limestone, bare of soil. Search invariably shows debris of associated rock, greywacke or spilite as the case may be, as soon as one steps off a bare limestone patch, no matter how bizzare its outline. Moreover, numerous exposures of sheared contacts and of discordant dips show that the blocks are tectonic. Some, of courseware composite, consisting for instance of limestones with accompanying interbedded spilites. The block fragmentation of the Steinmann trinity is also self-evident wherever soil has been washed away. It is advertised by sharp colour and structural contrasts among the component rocks.

(3) The general elongation of component blocks throughout the Ankara melange tends to be North-Easterly. Though contacts are greatly sheared the interiors of limestone blocks are. often massive and there are numerous exposures of undeformed pillow lavas. Where shearing and folding are prominent a crude cleavage is general. The grgywackes and accompanying shales are much more broken down- and sheared than the limestones.

(4) A group of anticlinal outcrops centered about Alaca Höyük shows the Ankara melange reappearing from under the Eocene. They leave no doubt that the Ankara melange continues without change of style, not only Eastwards as far as Alaca Höyük, but also for beyond this ancent site and modern village.

(5) Although the breaking and mixing of the components of the melange are wonderful to behold, it is evident that it is not complete, since there is a marked tendency for certain types of rock to maintain an irregular association. For exemple, large areas, predominantly formed of the Steinmann trinity, have been picked out, more or less faithfully, on existent maps. As these areas generally adjoin the Eocene cover, it is certain that at the time of its formation the upper portion of the melange was formed from what was previously the upper portion of the affected stratigraphical column.

(6) The melange in places assumes an appearance of Schuppen - struktur, but not with sufficient regularity to warrent deductions regarding the movement responsible, for its production.

(7) Eocene conglomerate - breccias rest on the melange and present a patent contrast between submarine-and subterranean accumulation. The Eocene has derived much of its material from the melange, including occasional limestone blocks measuring tens of metres, and obviously distributed by tunamis.

(8) The Eocene is sharply folded with dips ranging to vertical and this adds to the difficulty of interpreting the attitude of blocks contained in the melange.

(9) Among the serpentines and radiolarites of the Steinmann trinity we found in five independet exposures

variations of the following succession: serpentine; some few metres of calcitised serpentine veined by rather crystalline sedimentary - looking limestone; a small thickness of the same limestone, well bedded; thick radiolarian cherts. These left us in no doubt that many of the serpentines of Turkey are submarine lava flows. Such a conclusion would probably have been reached long ago in this or other regions, if it had not been for the large size of the original olivine crystals, a size that proclaims plutonic growth. Fortunately, N. L. Bowen, the latest of Wallaston medallists, has argued on laboratory and field experience that the great bulk of the crystallisation of the original peridotites, form which commonly serpentines have been derived, was completed before the crystal-concentrate plus lubricant-liquid undertook its last journey.

(10) Obviously the radiolaria of the Steinmann trinity have fed on silica - water, supplied not only by submarine, pillow, spilite lavas, as Dewey and Flett have so well maintained (1911), but also by submarine, peridotite flows.

(11) There are features of the Steinmann trinity, such as a frequent association of interbedded fine-grained greywacke, which suggest that Steinmann was wrong in assuming great depth of sea at the time of its formation. On the other hand until peridotite or serpentine lavas are found among terrestrial accumulations, it is plausible to argue that considerable hydrostatic pressure is necessary for their outpouring.

(12) We have mentioned under Reading (4) how the Ankara melange, exposed in the Ankara anticlinal, reappears eastwards in the Alaca Höyük group of anticlinals. The width of separating Early Tertiary outcrop occupying the intervening synclinal is, in this traverse, 60 km. This synclinal outcrop diminishes greatly northwards past Çankırı, but it increases correspondingly southwards and eastwards past Kırşehir, after which the synclinal may be named.

(13) A remarkable feature of the Kırşehir synclinal is that its Early Tertiary outcrop is in very many places interrupted by great spreads of marble and crystalline schists intruded by granite or diorite. These rocks are clearly pre-Tertiary; they pass under the adjoining Tertiary and have yielded debris to the same, Similar rocks are found occasionally in direct contact with the assemblage characteristic of the Ankara melange. We shall speak of these crystallines as the Kırşehir crystallines.

(14) The highly accentuated synclinal disposition of the Kırşehir crystallines with reference to the Ankara melange shows that the former constitute part of a great nappe de recouvrement covering the latter. In the anticlinal areas the Early Tertiaries rest preferentially on the melange, because the anticlines originated with conconimittent erosion before the early tertiaries started to accumulate. In the synclinal areas the early Tertiaries rest preferentially on the Kırşehir crystallines, because here erosion has spared extensive masses of the nappe de recouvrement.

(15) We believe that the Kırşehir nappe is most probably a Pontine nappe, and that the thrust at its base, which we suggest be called the Anatolian thrust, is essentially a boundary between Pontine (Black Sea) and Taurus (Mediterranean) pre-Tertiary

rocks, which differ in facies. The Ankara melange we interpret as Taurus rocks beneath the Anatolian thrust; the Taurus Mountains as a continuation of the similar rocks bulldosed towards the South.

(16) The horizontal displacement postulated along the Anatolian thrust amounts to about 350 km. This is greater than the minimum displacement measured along other thrusts as yet described. The Törnebohm thrust in Scandinavia has a minimum displacement of about 130 km.

(17) We are conscious that our conclusions differ considerably from Kober's conception of a Zwischengebirge between the Pontic and Taurus mountains (1931), and also from Parejas' interpretation of transversal anticlinals and synclinals in the same region (1940).

In conclusion we wish to express our warmest thanks to Professor Pamir, Director general of M. T. A., and Dr. Recep Egemen, Director of the Geological Branch of the same, for their constant help during our sojourn in Turkey.

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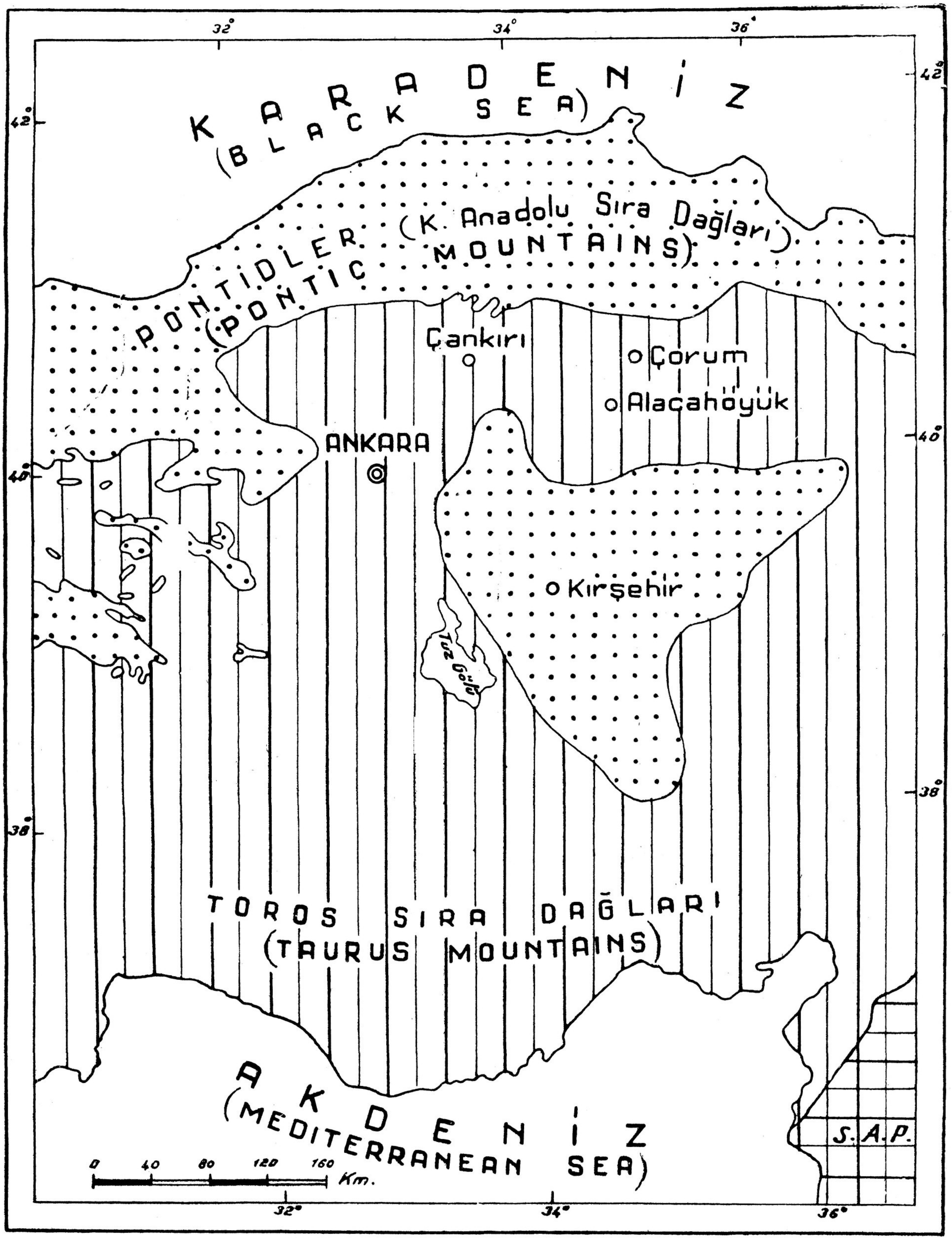


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*Şekil. 1. Pontid ve Taurid sahreleri birbirinden ayıran Anadolu Şariajı ilk şematik krokisi. Buradaki Tersier ve Kuatermer örtü kaldırılmıştır.*
*S. A. P. = Suriye - Arap Platformu.*

*Fig. 1. First sketch of Anatolian Thrust separating Pontic from Taurus rocks, stripped of Tertiary and Quaternary cover.*
*S. A. P. = Syro - Arabian Platform.*