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CHAPTER VI

MODERN GEOLOGY OF THE URAL MOUNTAINS

INTRODUCTION

The Urals belong to the Hercynian orogenic system and began as a rift system between the Fenno-Sarmatien shield in the West and the Tobolsk shield in the East. The north-south trend of the chain is bent around the Ufa Plateau.

A synthesis based on numerous works (Garan, Gorsky, Koptev-Dvornikov, Kuznetsov, 1937, Aladanskii and Sobolev, 1956) shows that the Urals consist from west to east of several major structural units which are as follows. A foreland represented by the Permian Ufa Plateau; a western slope consisting of westward thrusted sedimentary rocks of a foredeep basin; a Precambrian geanticlinal wedge (Ural-Tau) almost in vertical position, forming the highest crest of the range and the watershed line; a zone of basic and ultrabasic and mineralized intrusives immediately adjacent on the east to the geanticline; and a highly folded and complex zone of metamorphics of green schist facies associated with radiolarian cherts, jaspers, and abundant ophiolites, andesites, and basalts. This zone represents the main trough of the Urals characterized by extensive and long-lasting submarine and island-arc volcanism. Granitic batholiths of Hercynian age intruded this metamorphic zone in many places, but tend to form a major and more continuous belt along its eastern margin. The easternmost margin of the chain, particularly in the southern Urals, consists of a tightly faulted and intruded metamorphic-sedimentary belt, thrusted eastward and eventually covered by Jurassic to Cenozoic clastics. These in turn are overlain by Pleistocene glacio-fluvial gravels and sands of the Siberian Plains.

Morphologically, the highest points and the watershed line of the Urals are located along the Precambrian metamorphic zone which resisted best to denudation. The elevation is 1600 to 2000 m in the north, 600 m in the central Urals, and 1000 m in the south. The western slope is really an uplifted plateau, 500 to 600 m high, dissected by streams into flat hills. The eastern slope is a gently sloping surface with numerous ridges corresponding to basic intrusions and granitic batholiths. Its average elevation is 150 to 200 m.

Bubnoff (1926, 1952) divided the Urals into 6 major longitudinal zones separated from each other by major thrusts (Fig. 2). This division has been generally accepted (Saforov, 1937; Termier and Termier, 1956) and is described below in more detail from west to east.

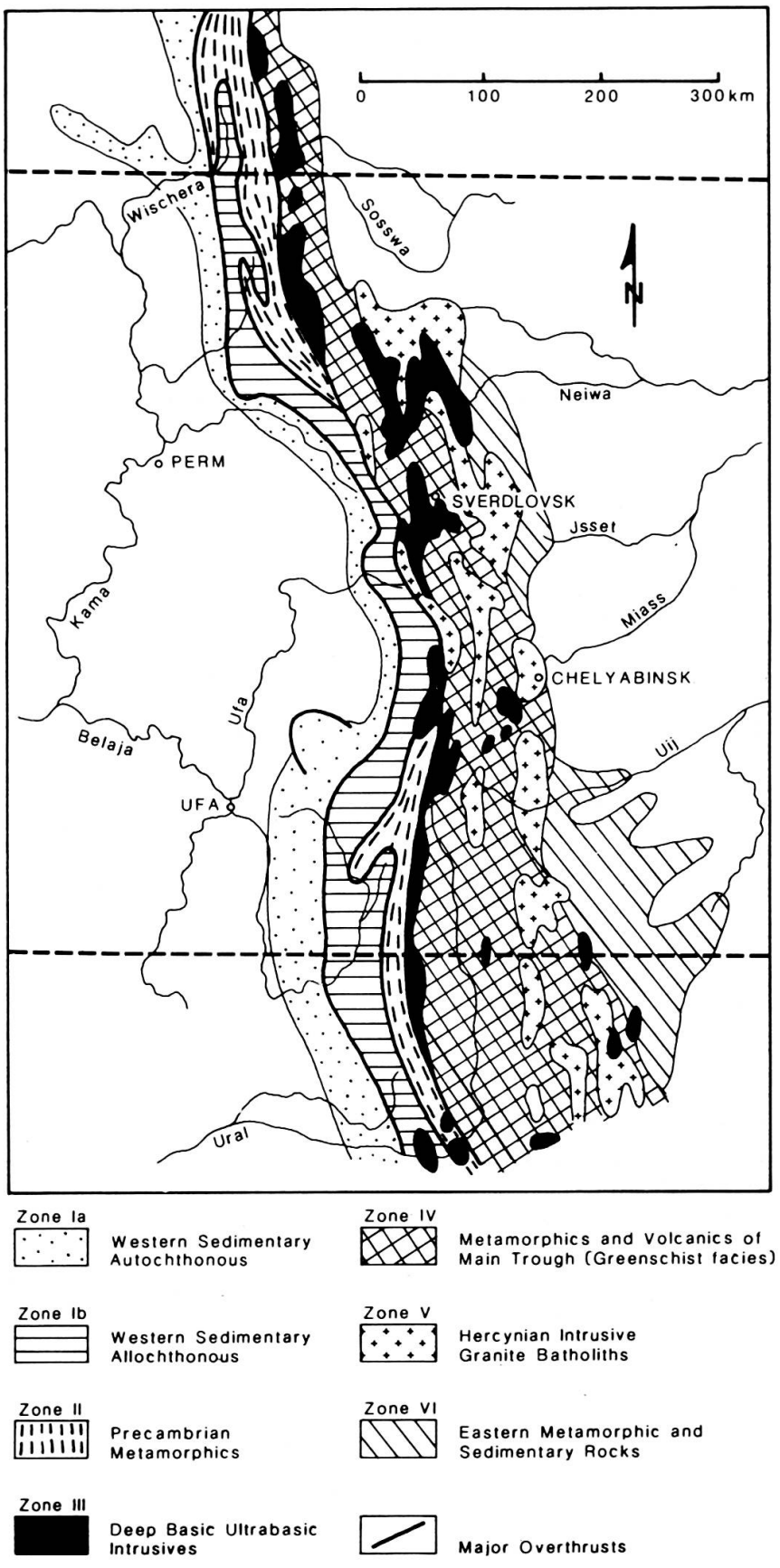

FIG. 2.

Structural map of the central Urals and their bend against the Ufa foreland. Modified from Bubnoff (1952). Dashed E-W lines indicate the boundaries of Pallas' geological map (1773).

Zone Ia. Western sedimentary autochthonous

It consists of flat beds becoming increasingly folded toward the east until the overthrust plane of the next zone Ib. The sequence consists of complete Carboniferous with Tournaisian limestones grading upward into sandstones, shales, and coal beds; widespread and fossiliferous Viséan limestones with *Productus* and the coral *Dibunophyllum;* Namurian-Moscovian limestones with *Choristites mosquensis.* The overlying Permian is as follows: Artinskian conglomerates, sandstones, shales, and arenaceous limestones; Kungurian dolomites, limestones, gypsum, evaporites, sandstones, and shales; Kazanian sandstones, conglomerates, and marls.

Zone Ib. Western sedimentary allochthonous

This zone consists of a highly folded sequence in numerous isoclinal structures between westward oriented thrusts which terminates eastward by a complex fan-shaped structure against the Precambrian geanticlinal wedge of the next zone III. The sequence of zone Ib ranges from Cambrian to Carboniferous, with Cambrian-Ordovician in the fan-shaped structure adjacent to the geanticline, followed westward by Silurian beds, then by large overthrusts with Carboniferous coal beds in overturned synclinal position with underlying Devonian. The sequence is as follows. The Cambrian consists of alternating phyllites, quartzites with unfossiliferous to poorly fossiliferous limestones and dolomites with *Archaeocyathus.* The Ordovician shows bituminous shales with graptolites and a first volcanic episode of gabbros and diabases. The angular unconformity of Mugojary between Ordovician and Silurian represents the Taconic orogeny. The Silurian consists of gray to yellow limestones and dolomites with rare fauna of brachiopods, ostracods, and corals. The Devonian is an association of sandstones, shales, rare limestones, and bituminous shales with Goniatites. The Carboniferous is similar to that of zone Ia with abundant coal beds and widespread limestones with *Productus.*

Zone II. Precambrian (proterozoic) metamorphics

This central geanticline, not recognizable in the central Urals, is limited on both sides by high-angle thrusts dipping in opposite directions. Between them, are numerous isoclinal folds with high development of schistosity. The metamorphics of epizone to mesozone type are micaschists, quartzites, feldspathic quartzites, and rare gneisses associated with abundant amphibolites representing metamorphosed porphyrites, gabbros, and gabbro-diorites. In the region of Bakal-Satka-Kusal, the Proterozoic is overlain unconformably by a very thick sequence of Eocambrian molasse-type clastics with a few limestones with *Archaeocyathus.*

Zone III. Deep basic to ultrabasic intrusives

This zone consisting of diorites, gabbros, peridotites, and often serpentinized dunites still shows an eastward dipping attitude. It is continuous in the northern and southern Urals, but divided into isolated patches in the middle Urals where it may occur on both sides of the Precambrian ridge. It is the equivalent of a serpentine belt.

Zone IV. Metamorphics and volcanics of the main trough

The metamorphic rocks of this zone belong to the greenschist facies. They are associated with abundant ophiolites, andesites and basalts, graywackes, radiolarites, and red jasper. They have been folded in a complex manner but erosion has destroyed most of the structures leaving only vertical and eastward thrusted sequences separated by scattered basic intrusions and Hercynian granitic batholiths. The sequence of this zone is as follows. Upper Silurian: porphyrites, diabases of Nijni-Tagil, green schists. Lower Devonian: porphyrites, diabases, red jasper, and marbles. Middle Devonian: abundant red jasper, albitophyres, tuffs, green schists, rare limestones with *Pentamerus*. Upper Devonian: green graywackes, radiolarites, diabases. Lower and Middle Carboniferous: porphyritic basalts, quartz porphyries and tuffs which represent the last products of this volcanized and highly metalliferous belt. The repeated association of graywackes — schists — variegated radiolarites (jasper) — ophiolites indicates a typical subduction zone.

Zone V. Hercynian intrusive granitic batholiths

Although intrusive granites occur scattered within zone IV, most of them form a more continuous zone along its eastern margin which can be considered an entity in itself. Numerous types occur which are very pneumatolitic, including rapakiwi granites. They were intruded during late Carboniferous, between Bashkirian and Moscovian, taking advantage of the location of ultrabasic intrusions within the green schists of the main trough.

Zone VI. Eastern metamorphic and sedimentary rocks

This tight isoclinally folded, faulted, and eastward thrusted belt is similar in some aspects to zone IV of the main trough, but is at the same time one of the most characteristic zones of the Urals. The sequence is as follows. Silurian: green schists, diabases, and porphyries. Devonian: porphyrites, diabases, graywackes and

limestones. Lower Carboniferous: sandstones, shales, coal beds, and Viséan limestones with *Productus giganteus* and *P. striatus,* porphyritic basalts, quartz porphyries, diabases, and tuffs. Middle-Upper Carboniferous: sandstones, conglomerates, rare limestones with *Choristites mosquensis* (Moscovian). The Carboniferous is distinguished by many emergences, volcanic activity, and displays more coal beds than on the western flank of the Urals. Typically of this zone, most of the diabases, diorites, and porphyries were intruded as large vein-like bodies along the fractures of a phase of brittle deformation following the main orogeny, and not before as in zone IV. Consequently, metamorphism is well developed but of variable intensity, and many coal beds are locally changed into anthracite or graphitic schists. The rocks of the Eastern Flank disappear under the Mesozoic-Cenozoic sediments of the Siberian plains.

Post-Tectonic evolution

The major episode of folding and thrusting in opposite directions took place at the limit Ouralian-Artinskian, and was preceded by granitic intrusions. During late Triassic, the chain underwent a period of intense erosion which eventually unroofed the granitic batholiths intruded in the green schists. Continental beds of the Lower Jurassic where then deposited over peneplained surfaces as extensive sands, clays, bauxites, oolitic iron ores, and brown coal. A marine transgression from the east began in the Cretaceous and may have reached the Precambrian axis. It culminated with the Upper Cretaceous with phosphatic glauconitic sandstones and continued during the Lower Cenozoic before ending in continental beds. The Pleistocene consists of lacustrine peat, outwash gravels and sands with bones of mammoth in the Siberian plains under the influence of glacial deposits in the Northern Urals, and of Recent deposits of gold and platinum placers.

Tectonic comparison of the Urals with the Alps

Bubnoff (1952) compared the structure of the Urals (Fig. 3) with that of the Alps as follows. Zones Ia, Ib, and II represent the Helvetic nappes of the Alps with their associated Hercynian massifs and wedges. Zones III and IV are equivalent to the Pennine metamorphic nappes, whereas zones V and VI would correspond to the Austro-Alpine overthursts. However, in the Alps the important N-S compression has thrusted the various structural units on top of each other in a northward direction, whereas in the Urals, the weak E-W compression has been unable to have such an effect so that the various structural zones are still next to each other in their original position. They are only involved in a general fan-shaped system which consists of thrusts of appreciable amplitude, but in no way comparable to Alpine nappes.

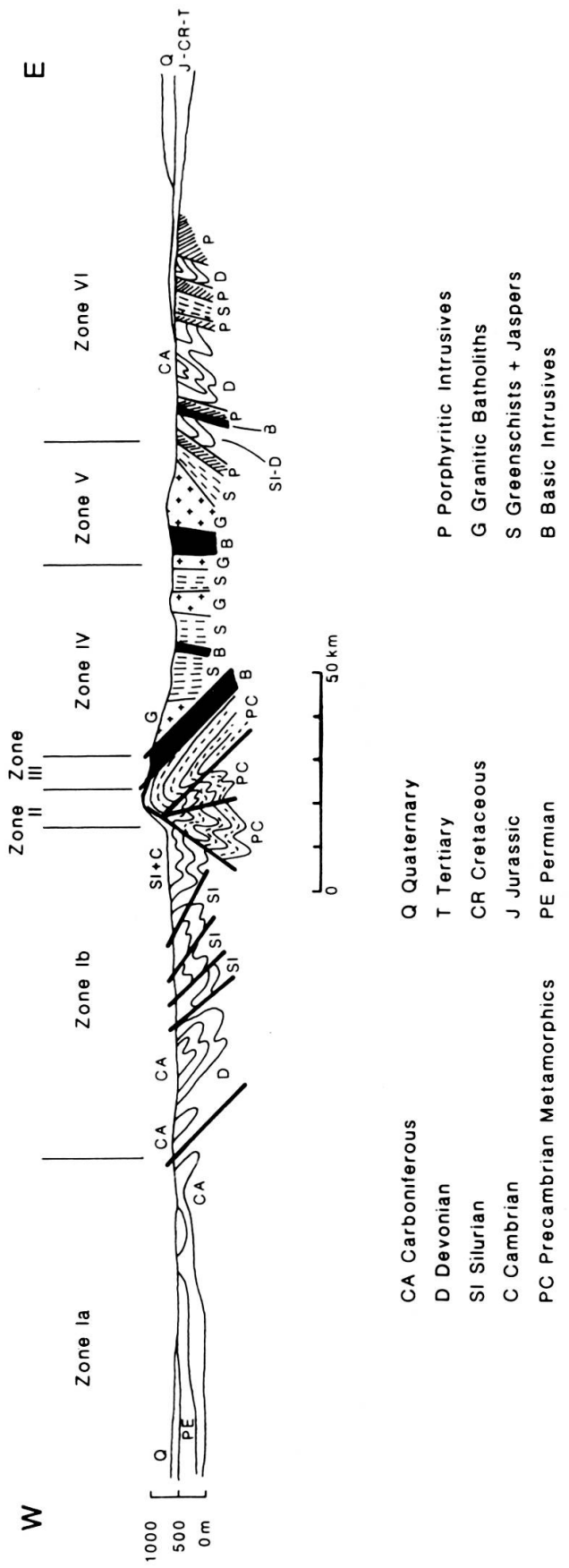

FIG. 3.

Schematic E-W geological cross-section of the southern Urals with the structural zones of Bubnoff (see Fig. 2). Modified from Garan, Gorsky, Koptev-Dvornikov, and Kuznetsov (1927).

REFERENCES

ALADANSKII, P. I. and I. D. SOBOLEV (1956). *Geological Map of the Urals* 1: 5,000,000, Moscow, Chief Administration of Geodesy and Cartography of the USSR.

BUBNOFF, S. VON (1926, 1930). *Geologie von Europa,* vol. I, *Einführung, Osteuropa, Baltischer Schild:* Geologie der Erde, Berlin, Borntraeger, 71-116.

—— (1952). Neue Geologische Forschungen im Ural in ihrer grundsäztlichen Bedeutung: *Abhandl. Deutsche Akad. Wissenschaft zu Berlin, Kl. Mat. und allg. Naturw.,* 1951, No. 3, 18 p.

CHIEF ADMINISTRATION OF GEODESY AND CARTOGRAPHY OF THE USSR (compilator) (1956). *Tectonic map of the Urals* 1: 7,500,000, Riga.

GARAN, M. (1937). Bakal-Satka-Kusa region (South Urals): *Internat. Geol. Congress, XVII Session, USSR, Uralian Excursion. The southern part,* p. 32-39.

GORSKY, I. (1937). The geology of the eastern slope of the Urals along the route from Cheliabinsk to Orsk: *Internat. Geol. Congress, XVII Session, USSR, Uralian Excursion. The southern part,* p. 69-71.

KOPTEV-DVORNIKOV, V. (1937). The geology of the Urals along the South-Ural railway (Cheliabinsk-Zlatoust): *Internat. Geol. Congress, XVII Session, USSR, Uralian Excursion. The southern part,* p. 113-122.

KUZNETSOV, E. A. (1937). General geology of the Urals: *Internat. Geol. Congress, XVII Session, USSR, Uralian Excursion. The northern part,* p. 11-20.

—— (1937). Perm-Pashia-Kushva-Tagil-Sverdlovsk-Bazhenovo: *Internat. Geol. Congress, XVII Session, USSR, Uralian Excursion. The northern part.,* p. 21-26.

SAFOROV, I. (1937). Orogeny of the Urals: *Am. Assoc. Petroleum Geologists Bull.,* 21, 1439-1463.

TERMIER, H. et G. TERMIER (1956). *L'évolution de la lithosphère, II Orogenèse (premier fascicule),* Paris, Masson et Cie, p. 358-367.