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Eduard SUESS and Russian Geologists

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15 Text-Figures

Geschichte der Erdwissenschaften
Altai-Gebirge
Siberischer Kraton
Russischer Kraton

Contents

Eduard SUESS und russische Geologen

Zusammenfassung

Zahlreiche Zitate von russischen Quellen in „Das Antlitz der Erde" demonstrieren klar ihre Bedeutung für das Konzept der Altaiden. Die SUESS-Briefe an Vladimir OBRUCHEV, die bei der internationalen Geologenschaft beinahe unbekannt sind, zeigen, wie eng die Beziehungen zwischen Eduard SUESS und russischen Geologen gegen Ende des 19. und am Beginn des 20. Jahrhunderts waren. Sie erklären auch, wie das großtektonische Konzept von Asien (SUESS, 1901) entstand und ausgebaut wurde. SUESS hatte die vage Idee einer zentrifugalen Ausbreitung von „Altaiden-Wellen", ausgehend von einem kontinentalen Kern irgendwo in Sibirien; dieses gewann klare Konturen nach der Lektüre einer Publikation von Iwan TSCHERSKI, der 1886 ein

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ähnliches Modell vorschlug. OBRUCHEV hatte diese Arbeit für SUESS übersetzt und sie mit einer eigenen Karte zur Erklärung von TSCHERSKIS Ideen ergänzt. Zur Zeit seiner ersten Kontakte mit SUESS im Jahre 1891 war OBRUCHEV ein junger Wissenschaftler, der bereits gegen Ende des 19. Jahrhunderts ein berühmter Erforscher Asiens wurde. Seine freundschaftliche und herzliche Beziehung zu SUESS erleichterte einen ständigen Fluss von Daten (manchmal direkt aus dem Gelände) und Publikationen in beiden Richtungen, die den Asien-Studien sehr zugute kamen. Dadurch war SUESS auch über nachrangige Details der Beschreibungen russischer Geologen informiert. Der Erfolg der Asien-Studien war nur durch den Zugang zu russischen Daten möglich. SUESS lernte sogar Russisch – ein Beweis von Hingabe an die Sache, wie er heutzutage kaum denkbar ist.

Neben den Altai-Bögen und Beschreibungen beinahe aller geologischen Strukturen im nördlichen Asien und in China bezog SUESS von Russen das Konzept der „disjunktiven Dislocationen“, die er in seiner tektonischen Karte in leuchtenden Farben darstellte. Gleichzeitig hing SUESS sehr an Theorien des strikten Zusammenhanges zwischen Orographie und Tektonik und beachtete nicht genügend die russischen Beobachtungen von Widersprüchen zwischen den Streichrichtungen von Falten und Gebirgszügen, überprägenden Faltungen, Mélange-Strukturen, etc.

„Das Antlitz der Erde“ wurde von russischen Geologen mit großer Begeisterung aufgenommen. Als der dritte Band, der sich besonders Asien widmete, erschienen war, wurde SUESS in die Russische Akademie der Wissenschaften gewählt und besonders geehrt. Russische Enzyklopädien und Publikationen zur Geschichte der Naturwisssenschaften lassen immer noch die positive Einstellung zu SUESS und seinem Werk erkennen. Trotzdem und im Gegensatz zu vielen anderen klassischen Werken westlicher Geologen wurde SUESS aus ungeklärten Gründen niemals ins Russische übersetzt. In den 30-er und 40-er Jahren verschwand der Name SUESS allmählich aus den Literaturverzeichnissen russischer Publikationen. Missinterpretationen und Missverständnisse der Ansichten von SUESS durch Anhänger der Geosynklinaltheorie waren ebenfalls ein Ursache dafür, dass die SUESSschen Konzepte in Vergessenheit gerieten. Beispiele dieser bedauerlichen Fehler sind leicht zu finden, betrachtet man die Ideengeschichte des Sibirischen und Russischen Kratons.

Das vorbildliche Verhalten der wichtigsten Proponenten der geologischen Erforschung Asiens zu Ende des 19. und zu Beginn des 20. Jahrhunderts ist lehrreich und bewundernswert. Das Werk von SUESS und seiner russischen Freunde verdient zusätzliche und intensive Studien.

Abstract

Numerous citations of Russian sources in “The Face of the Earth” clearly demonstrate their importance for the creation of the Altaid concept. SUESS' letters to Vladimir OBRUCHEV, which are almost unknown to the international geologic community, show how close the relationships between Edward SUESS and Russian geologists were at the end of the 19th and the beginning of 20th century and explain how the great tectonic concept of Asia (SUESS, 1901) was born and bred. SUESS' vague idea on centrifugal spread of the Altaid waves from a continental nucleus located somewhere in Siberia, took a clear form after his acquaintance with Ivan TSCHERSKI'S (CHERSKIY) paper who suggested a similar model in 1886. OBRUCHEV kindly translated this paper for SUESS and supplemented it with his own map explaining TSCHERSKI'S ideas. Being a young scientist at the time of his first contact with SUESS in 1891, OBRUCHEV became a renowned explorer of Asia already by the end of 19th century. His friendly and cordial relationships with SUESS facilitated a continuous flux of data (sometimes directly from the field) and publications in both directions for the great benefit of Asiatic studies. Because of it SUESS was aware about minor details of geologic descriptions published by Russian geologists. Understanding that success in Asiatic studies is impossible without access to Russian data SUESS managed to learn Russian – a demonstration of aspiration that is almost totally missing among modern researchers.

Besides the Altaid arcs and geologic descriptions of almost all geologic structures in northern Asia and China, SUESS borrowed from Russians the concept of disjunctive dislocations, using most vivid color in his tectonic map to show them. At the same time, SUESS' adherence to orography in tectonic research did not allow pay due attention to Russian discoveries of disagreements between trends of folds and trends of mountain ranges, superimposed folding, mélange-type structures, etc and incorporate them in his synthesis.

“The Face of the Earth” was greatly welcomed and appreciated by Russian geologists. When the third volume devoted to Asia was published, SUESS was elected to the Russian Academy of Sciences and got an honorable award. A positive attitude to Suess and his work is still evident from Russian encyclopedias and publications on history of sciences. Nevertheless, to the contrary to many other classic works of western geologists SUESS' writings were never translated into Russian for some unclear reasons. In the 1930–1940's SUESS name gradually disappeared from lists of references in Russian publications. Besides, misinterpretation and misunderstandings of SUESS by proponents of the geosynclinal theory were also an important aspect of the oblivion of SUESS' concept. Examples of these lapses are self-evident if one looks at history of ideas on the Siberian and Russian cratons.

Truly gentlemanly behavior of the key players in Asiatic research at the end of the 19th and beginning of the 20th centuries is very instructive and admirable. The work of SUESS and his Russian friends deserves additional and more thorough studies.

1. Introduction: How I learned about Edward SUESS

My first term paper in the Saint Petersburg University was entitled “Origin of mountain belts: History of ideas”. My teacher, Prof. Georgy PORSHNYAKOV, strongly recommended me to read a book “Origin of mountain ranges and mineral deposits” by academician Vladimir Afanasyevich OBRUCHEV that was originally published in 1932 (OBRUCHEV, 1942).

I barely remember what I wrote in my term paper, but the name of the great Austrian geologist Edward SUESS had become imprinted in my memory through this reading. OBRUCHEV discussed in detail various tectonic hypotheses starting with XENOPHANES, HERODOTUS, and other ancient great thinkers. He was neutral vis-à-vis the ideas of the ancients, but he criticized the authors of the later hypotheses starting with the 17th century and his criticism became stronger as he moved towards his contemporaries.

Concerning SUESS, OBRUCHEV said only that some of his statements would be corrected, as new data will be obtained in this or that region. This mild criticism looked strange for me because Suess was defined as the founder of a new era in geology. OBRUCHEV (1942, p. 21) emphatically stressed that

> *“The Face of the Earth” will forever stay as the treasury, from which many generations of geologists will ladle knowledge of geological ideas in the past and in which they will find assignments for their future research.”*

I must confess that I have learned only a little about SUESS during my study at the university. However, when I moved to Khabarovsk, a city in far eastern Russia, I met a geologist who lived and worked in a remote settlement in Siberia for many years and thus had had a limited access to a good library. Nevertheless he spoke about SUESS with great reverence. Being alarmed of my ignorance, I went to the library and found out that SUESS' name is absent in the catalog. His publications were not translated, though papers and books of many other foreign geologists were translated and were easily available. Thus, my attempt to learn about SUESS from a primary source has failed.

During my following professional activity I met references to SUESS here in there gradually learning about his ideas on the Ancient Vertex of Asia, its successive overgrowth by younger mountain ranges, asymmetry in structure of many mountain ranges, the concept "Tethys", etc. Unfortunately all the information I obtained had been gathered from secondary sources.

2. Attitude towards SUESS in Russian Geological Literature

Any respectable Russian encyclopedia contains an article about SUESS. They inform the reader that besides enormous contributions to geology SUESS has introduced the term biosphere (any educated Russian is convinced that the founder of the science about the biosphere is Vladimir Ivanovich VERNADSKY (1863–1945). A reader can learn that SUESS was somehow involved in the discovery of radioactivity after sending to the CURIES uranium ore.

In 1887, Edward SUESS was elected as a Corresponding Member of the Physical-Mathematical Division of the Russian Academy of Sciences and in 1901 he was elected as an Honorary Member in the same division. His photograph and short biography can be found in the internet site of this institution (http://www.pran.ru/rus/). In 1902, the Russian Geographic Society awarded E. SUESS by the golden medal of N.I. SEMENOV (Tienshansky) for the third volume of his "The Face of the Earth".

Interestingly, other great European geologists such as STILLE, KOBER, or ARGAND were not elected to the Russian Academy despite of a very positive attitude to their works. Their important publications were translated into Russian and were well known and popular among Russian geologists. STILLE was especially popular with his concept of phases of folding that provided an easy method for correlation. In 50s and 60s, this concept was not the interest of only academic geologists. Extensive mapping of the whole of the country required a method and the rule "the cheaper is the better" always plays its role. STILLE is the only non-Russian geoscientist for whom the Soviet Academy of Sciences actually published a book of selected works („Izbrannie Trudy").

I am not aware of any serious criticism of SUESS' ideas by Russian geologists except his concept of the Ancient Vertex while it is not a big deal to find a paper stating that CUVIER's ideas are incompatible with modern geology, STILLE's concept of orogenic phases is wrong or HAUG's interpretation of geosyncline development is too schematic. There are papers about SUESS' life and scientific activity published in academic journals (KHOMIZURI, 2002). OBRUCHEV's book about SUESS was published twice (OBRUCHEV & ZOTINA, 1937; OBRUCHEV, 1964).

Thus, on one hand, we see a very positive attitude of Russians towards SUESS but on the other hand his works were not translated[1)] and therefore the majority of citations are "second hand" citations. The absence of translations is surprising because publications of prominent foreign scientists were usually translated into Russian. During the socialist times, there was a special publishing house for these purposes. Was it because SUESS' understanding of the structure of Asia was too schematic or his model of the evolution was too wide, if it was evaluated from Popperian point of view and thus it had no interest? It is not the case. I can give you one example.

My knowledge about boundaries, structure, and history of the Siberian craton is based on works of hundreds of geologists who mapped the region in scale 1 : 200 000 and larger, who did geophysical explorations there, detailed stratigraphic studies, etc.

Reading SUESS and keeping in mind the date of this publication I am completely satisfied with his description of boundaries of the East Siberian tableland. His description is good enough to describe craton's boundaries in a modern paper. SUESS started Paleozoic stratigraphy of the cratonic cover with Cambrian deposits emphasizing the presence of salt and gypsum as if he was sending a message to geologists of 80's who, because of a lack of paleomagnetic data, used this paleogeographic indicator to determine a former low latitude position of the Siberian craton in their first plate tectonic reconstructions.

Interestingly, SHATSKY's paper, which was published in 1932 (SHATSKY, 1964a) and which was considered by many Russian geologists as the primary paper in shaping the modern understanding of the Siberian craton, does not give information about these evaporites. Systematically describing exposures of the Cambrian in various places of the East Siberian Tableland and unconformable relationships of Cambrian rocks with underlying gneisses and schists SUESS suddenly points out that in one place altered clays appear beneath Cambrian sediments (SUESS, 1908, p.18). As we know now, the sedimentary cover of the Siberian craton starts with the Riphean rocks that were discovered in the craton about 20 years later and that was not mentioned at all in SHATSKY's 1932 paper.

The beginning of the 20th century was a time of almost "compulsory" citations of SUESS' publications in Russian geological literature. Reverence to SUESS' name that can be seen in books and papers written by OBRUCHEV, KARPINSKY, ARKHANGELSKY, PAVLOV, etc. SUESS' name almost vanished form citation lists in Russian literature in the 30's–40's or he was mentioned as the author of the now abandon concept of the Ancient Vertex of Asia. I guess that the same fate may be seen in international publications. I do not know exactly why it has happened.

I will try to outline the relationships of SUESS and Russian geologists at the transition between the 19th and the 20th centuries, which may explain why the reverence to Edward SUESS still exists and is still strong in my country. Hereafter I will suggest a possible explanation, why SUESS' name has gradually evaporated from Russian publications on regional geology of Siberia.

3. Beginning of the Altaids

After a short description of the orography of Siberia SUESS (1908) writes:

> *"In such ways does the landscape change its form; only if it were possible to colour in the outlines and compare the sunny gardens of Buitenzorg with the yellow and terraced landscape of the Chinese loess, or with clouds of mist which cover the frozen graves of so many noble explorers at the mouths of the Lena, only then should we gain a somewhat clear idea of the grandeur, the diversity, and the beauty of the subject to which this and the following chapters are devoted."*

Whose graves are there?

3.1. Ivan Dementyevich TSCHERSKI

One of these graves belongs to Ivan Dementyevich TSCHERSKI[2)] (1845–1892; Text-Fig. 1). This grave is not at

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1) I met the reference to "The Face of the Earth" in Cyrillic only once in MURZAYEV et al. (1959). This reference is E. SUESS. Lik Zemli, v. III, SPb. Quotation extracted by MURZAYEV et al. from this book is referred to the page number that does not fit the English translation of SUESS. Beside, the year of publishing is also different. OBRUCHEV (1937) in his thorough list of all publications related to Asia did not mention this translation. Instead, he indicated two reviews in Russian on SUESS third volume by BELSKY (1902) and BOGDANOWITSCH (1902).

the mouth of Lena but three rivers farther to the east, on the bank of the Kolyma River.

TSCHERSKI's life was arduous and intricate. Being born to a wealthy family of land-owning aristocrats in the Vitebsk province of Russia (DYBOWSKY, 1956; OBRUCHEV, 1956) he was sent to study to the Vilno[3] Institute for nobles. In 1863, he joined the Polish Revolt, was arrested, stripped of his privileges, and sent as an ordinary soldier to Omsk, a city in Siberia. After five years of military service he was ordered to stay in Siberia in exile.

During his military service, TSCHERSKI acquired an interest in natural sciences. Georgii Nikolayevich POTANIN (1835–1920), who later led several expeditions to Central Asia and who had been cited by Suess many times, gave TSCHERSKI a list of books for self-education, among which there was an introduction to geology. This book had defined TSCHERSKI's lifelong scientific interests. POTANIN was a supervisor in TSCHERSKI's first scientific work in which he disputed HUMBOLDT's idea on the former connection between the Arctic Ocean and the Aral Sea.

In 1871, TSCHERSKI got a permission to settle in Irkutsk where he started to work in a local museum. Using support of the Siberian Branch of the Russian Geographic Society, TSCHERSKI investigated Lake Baikal and its surroundings, made an expedition to the Transbaikal region during which he crossed the highland of Central Asia. In 1885, Russian Academy of Sciences asked TSCHERSKI to undertake geological studies along the post road Irkutsk – Urals. This study was accomplished in one year and its results (TSCHERSKI, 1888) were acknowledged as very successful. In the same year, TSCHERSKI moved to St. Petersburg where he started to work in the museum of the Russian Academy of Sciences.

For seven years he was processing his previous field data, publishing the results among which there was a short paper on tectonics of Siberia. Besides, he worked with data collected by the expeditions of Aleksandr Andreevich VON BUNGE and Eduard VON TOLL (another of the unknown Siberian graves; VON TOLL's death is believed to have been on the Lena Delta: VON TOLL, 1909) in northern Yakutia and Arctic islands. The later work resulted in a thorough description of Quaternary fossils and the history of Arctic.

Being impressed by TSCHERSKI's activity, the Russian Academy of Sciences suggested him to lead an expedition to Yakutia. The expedition started in 1891. From Yakutsk, a city on the right bank of the Lena River, TSCHERSKI moved to the east toward the Kolyma River. The winter of 1892 in Verkhnekolymsk had destroyed TSCHERSKI's health and he got tuberculosis. Despite continuous and exhausting coughing TSCHERSKI decided to continue the expedition and in May sailed down the Kolyma River. At the beginning, he worked himself; then because of the deterioration of his health, his wife took responsibility for observations while TSCHERSKI kept their records; finally, TSCHERSKI could not do even this work and transferred his job to his 12 year old son.

In July 7, 1892 TSCHERSKI died. His son also died in an expedition but 30 years later and farther to the east, in Komandor islands (CHERSKAYA, 1956).

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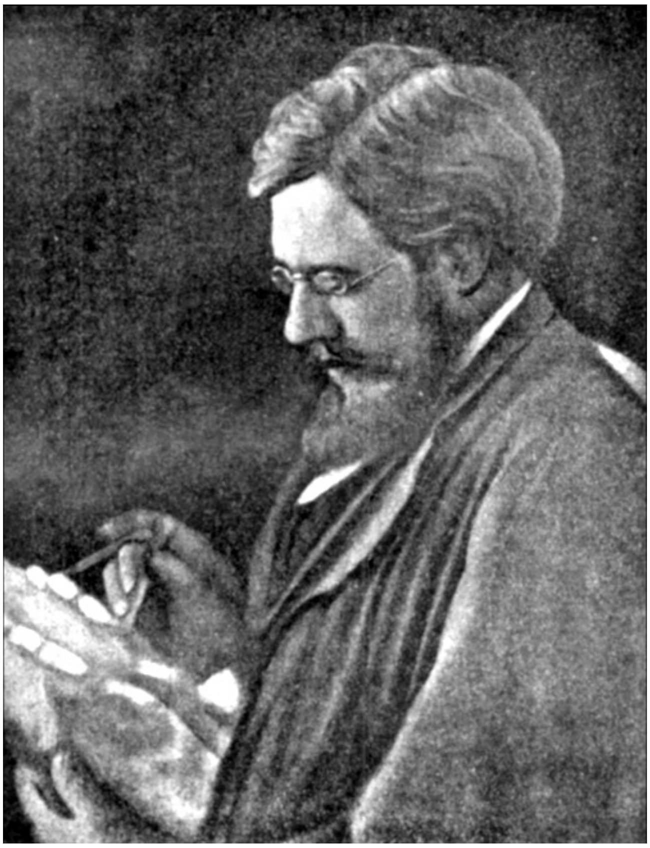
[2] Here I retain the transcription of the name given by E. SUESS. The English transcription, CHERSKY I. D., is better known mainly after geographic maps. A large range in northeastern Asia, the Khrebet Cherskogo (Chersky Range), is named after him.

[3] Vilno is official name of Vilnius till 1939.



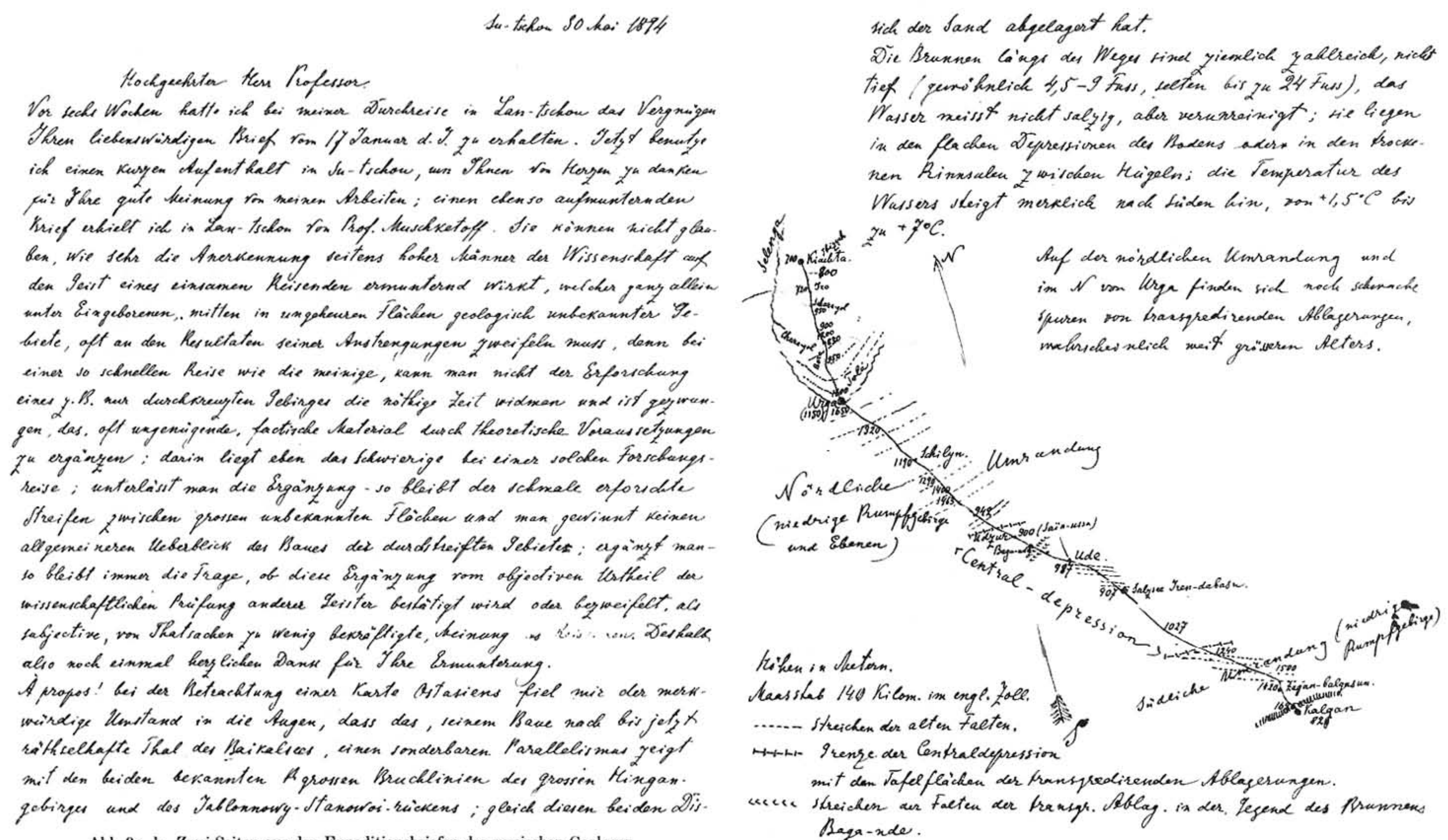
Text-Fig. 1.
Ivan Dementyevich TSCHERSKI (1845–1892).

3.1.1. OBRUCHEV Introduces TSCHERSKI to SUESS

In the third volume of "The Face of the Earth", SUESS indicated that a short paper written by TSCHERSKI had inspired his understanding of the structure of Asia (SUESS, 1908). This paper (TSCHERSKI, 1886) was published in Russian in the proceedings of the Russian Geographical Society that did not have a wide circulation outside Russia.

Circumstances that have helped SUESS to find and read this paper are of interest because they shed light on two important issues. First, they show that before his acquaintance with TSCHERSKI's paper, SUESS already had a preliminary idea on the structure of Asia but Tscherski's paper greatly facilitated in shaping and improving this idea. Secondly, these circumstances helped SUESS to establish close contacts with Russian geologists who in the second half of 19th century were very busy with geographic and geological exploration of Turkistan, Siberia, Far East, Arctic, Mongolia, and China. SUESS was lucky to establish friendly relationships with Vladimir Afanasyevich OBRUCHEV (see below) who at that time was a relatively young man but later became one of the greatest Russian geologists and geographers. Earlier, SUESS had communications with more senior Russian geologists such as Ivan Vasilievich MUSHKETOV (1850–1902) and Aleksandr Petrovich KARPINSKY (1847–1936) but because of OBRUCHEV these relationships had been transferred to a higher level – besides exchange of publications, SUESS received raw data directly from the field; in return, the Russians got help in fossil determinations from SUESS.

In 1964, the Academy of Sciences of the USSR published six volumes of selected publications of V.A. OBRUCHEV. In the forth volume there is a section named "Correspondence with E. Suess [1891–1914]" (OBRUCHEV, 1964). It consists of 60 letters from SUESS and only one letter from OBRUCHEV to SUESS. In the preface to that section, S.V. OBRUCHEV, son of V.A. OBRUCHEV, who was also a geologist and worked extensively in northeastern Russia, wrote that a search for other letters by OBRUCHEV was unsuccessful. Olga SUESS, the widow of SUESS' son, Franz Eduard SUESS, had informed him that SUESS' archives



Su-tschou 30 Mai 1894

Hochgeehrter Herr Professor.

Vor sechs Wochen hatte ich bei meiner Durchreise in Lan-tschou das Vergnügen Ihren liebenswürdigen Brief vom 17 Januar d. J. zu erhalten. Jetzt benutze ich einen kurzen Aufenthalt in Su-tschou, um Ihnen von Herzen zu danken für Ihre gute Meinung von meinen Arbeiten; einen ebenso aufmunternden Brief erhielt ich in Lan-tschou von Prof. Muschketoff. Sie können nicht glauben, wie sehr die Anerkennung seitens hoher Männer der Wissenschaft auf den Geist eines einsamen Reisenden ermunternd wirkt, welcher ganz allein unter Eingeborenen, mitten in ungeheuren Flächen geologisch unbekannter Gebiete, oft an den Resultaten seiner Anstrengungen zweifeln muss, denn bei einer so schnellen Reise wie die meinige, kann man nicht der Erforschung eines z. B. nur durchkreuzten Gebirges die nöthige Zeit widmen und ist gezwungen, das, oft ungenügende, factische Material durch theoretische Voraussetzungen zu ergänzen; darin liegt eben das Schwierige bei einer solchen Forschungsreise; unterlässt man die Ergänzung - so bleibt der schmale erforschte Streifen zwischen grossen unbekannten Flächen und man gewinnt keinen allgemeineren Ueberblick des Baues der durchstreiften Gebietes; ergänzt man - so bleibt immer die Frage, ob diese Ergänzung vom objectiven Urtheil der wissenschaftlichen Prüfung anderer Geister bestätigt wird oder bezweifelt, als subjective, von Thatsachen zu wenig bekräftigte, Meinung [illegible]. Deshalb also noch einmal herzlichen Dank für Ihre Ermunterung.

À propos! bei der Betrachtung einer Karte Ostasiens fiel mir der merkwürdige Umstand in die Augen, dass das, seinem Baue nach bis jetzt räthselhafte Thal des Baikalsees, einen sonderbaren Parallelismus zeigt mit den beiden bekannten grossen Bruchlinien des grossen Hingan-gebirges und des Jablonnowy-Stanowoi-rückens; gleich diesen beiden Dis-

sich der Sand abgelagert hat.

Die Brunnen längs des Weges sind ziemlich zahlreich, nicht tief (gewöhnlich 4,5–9 Fuss, selten bis zu 24 Fuss), das Wasser meisst nicht salzig, aber verunreinigt; sie liegen in den flachen Depressionen des Bodens oder in den trockenen Rinnsalen zwischen Hügeln; die Temperatur des Wassers steigt merklich nach Süden hin, von +1,5°C bis zu +7°C.

Auf der nördlichen Umrandung und im N von Urga finden sich noch schwache Spuren von transgredirenden Ablagerungen, wahrscheinlich weit grösseren Alters.

Höhen in Metern.
Maasstab 140 Kilom. im engl. Zoll.
------ Streichen der alten Falten.
+++++ Grenze der Centraldepression mit den Tafelflächen der transgredirenden Ablagerungen.
‹‹‹‹‹ Streichen der Falten der transgr. Ablag. in der Gegend des Brunnens Baga-nde.

Abb. 9a, b: Zwei Seiten aus den Expeditionsbriefen des russischen Geologen W. Obrutschew an Ed. Sueß aus Zentralasien.

Abb. 9a: Ausschnitt aus Briefen von Su-tschou in Dankbarkeit für die briefliche Verbindung mit Ed. Sueß auch im Gelände – der zu Beginn vom 30. Mai 1894 datierte Brief setzt allerdings auf Seite 6 erst am 23. Juli 1894 (bedingt durch Zeitmangel während der Forschungsreise) fort.

Abb. 9b: Aus Peking am 9. Jänner 1893 abgeschickt, enthält dieser Brief Routenskizze und zugehörige Erklärungen.

Text-Fig. 2.
OBRUCHEV'S letters to SUESS.

were destroyed during the Second World War together with SUESS'S summer cottage[4]. The surviving OBRUCHEV letter of April 20th, 1882, is of great importance, because it shows how the cooperation between SUESS and Russians has started.

The correspondence began in December 1891 when OBRUCHEV sent to SUESS his report on the investigation of the Olekma-Vitim gold-bearing region (OBRUCHEV, 1964). In his reply of July 6th, 1891 Suess expressed an interest in the strikes of folds in Siberia saying:

"I have received an impression that folds in Siberia are very old and that they form a gentle arc, convex to the south and constituting the High Plateau[5] of Central Asia. Thus, from Siberia to Himalaya there is only one system of folds and its internal Siberian arc is very old or at least older then the southern arc where Tertiary rocks are folded." (Obruchev, 1964, p. 245).

Knowing that similar ideas had been published in Russia, OBRUCHEV translated a paper written by I. TSCHERSKI and sent it to SUESS. In an accompanying letter he wrote:

"It seems that this paper is unknown to you otherwise I cannot explain why you, with your flattering question, applied to such a novice in the Siberian geology as myself, instead of directing your question to the best source – I. Tscherski" (Obruchev, 1964, p. 244).

TSCHERSKI (1886) divided eastern Siberia into the following orographic regions (Text-Fig. 3):

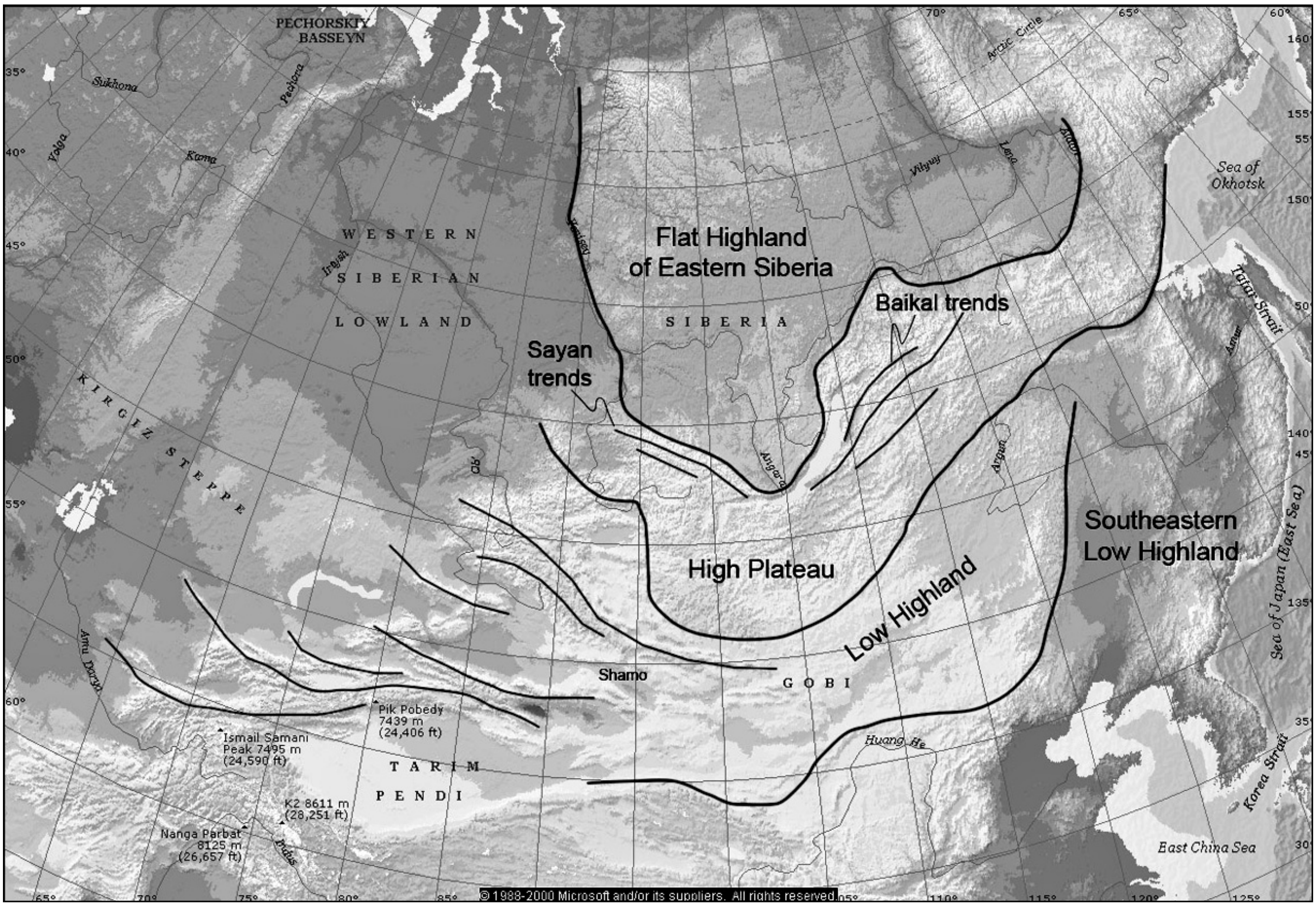
1) the Flat Highland of Eastern Siberia;
2) the High Plateau that consists of the Sayan, Baikal and Olekma mountains, the Yablonovyy Range, the Khangai, Hantei and Tannu Ola;
3) the Low Highland including the Gobi and the Shamo as well as the marginal range of the Khingan;
4) the southeastern low highland consisting of the Sikhote-Alin Range.

Each of these regions has a specific tectonic connotation. The High Plateau is an ancient continent that had never been covered by Paleozoic seas. It is characterized by two directions of folds one of which to the east of southern tip of the Baikal Lake trends northeast (the Baikal trend) while the second one to the west of Baikal trends northwest (the Sayan trend). Ancient folds do not follow topographic features, being obliquely cut by younger faults[6]. The age of these faults was not clearly determined. However, the Paleozoic displacements along them can be inferred from TSCHERSKI's statement that subsidence along the faults caused repeated Paleozoic flooding of the extensive region to the north of the High Plateau, namely the Flat

[4] It is diffficult to believe this story, first, because TOLLMANN (1983, Figs. 9a,b, Fig. 2 herein) reproduces two separate manuscript letters from OBRUCHEV to SUESS. Secondly, SUESS' summer house in Marz stands today (A.M.C. ŞENGÖR, personal communication, 2005). So the SUESS-OBRUCHEV correspondence is a subject where further research in Austria, Switzerland and the USA, where members of the SUESS family now reside, might be fruitful. It is of great importance that SUESS' correspondence be published as ŞENGÖR points out in his paper in this volume.

[5] The High Plateau is a term that has been suggested by KROPOTKIN (1875). It is not used in modern literature.

[6] Disagreement between topographic features and folding that was emphasized by TSCHERSKI (1886) is very important. In those days all tectonic syntheses of Asia and other regions were based on orographic features (VON HUMBOLDT, 1831, 1843a,b; RITTER, 1832; RICHTHOFEN, 1877;), an approach that was named by HUMBOLDT "orometric geology" (A.M.C. ŞENGÖR, unpublished manuscript on the history of geological exploration of Asia; see also ŞENGÖR, 1998).



Text-Fig. 3.
Structure of Asia reconstructed from TSCHERSKI'S (1886) paper.

highland of eastern Siberia or the Siberian craton as we now call it. Devonian seas also invaded the southern and southwestern margin of the High Plateau. Sediments deposited in these seas were later transformed in mountain ranges (folds!) that formed at margins of the High Plateau. In contrast to the High Plateau, these folds are parallel to the orographic ranges. Trends of the folds form a system of arcs that follow the geometry of the High Plateau with northeastern strikes in the east and northwestern strikes in the west. The Devonian Altay arcs disappear beneath the Mesozoic West Siberian Basin. Lying farther to the west, the Tarbagatai perhaps continues to Lake Balkhash. Then follow the Tien Shan arcs that in turn, here TSCHERSKI cites SUESS, continue to Europe through the Parapamisus, Kopet Dag, Caucasus, and the Balkan range. As we see from this paragraph, TSCHERSKI's idea on the structure of Northern Asian was only slightly modified by SUESS in the third volume of "The Face of the Earth".

TSCHERSKI's paper had no figures. To help SUESS to visualise what he said, OBRUCHEV drew a map of Siberia in which he indicated trends of old folds and trends of modern ridges as well as trends of faults mentioned by TSCHERSKI. OBRUCHEV added also that he shared TSCHERSKI's ideas and pointed out that the High Plateau was at least in places covered by early Paleozoic seas (Cambrian or early Silurian) and that the region was affected by the late Silurian folding in the northern Transbaikalia and in the Olekma-Vitim region (OBRUCHEV, 1964). OBRUCHEV added also that modern topography of the High Plateau was formed from a denuded surface that was also affected by Paleozoic folding. Thus, he emphasized the disagreement between ancient folds and modern ridges challenging the then widely accepted methodology in tectonic research developed by Elie DE BEAUMONT, VON HUMBOLDT, and VON RICHTHOFEN.

SUESS suggested a new name for the High Plateau – the Ancient Vertex – that essentially replaced the term High Plateau in the subsequent geological publications both in Russia and in the West. SUESS incorporated in his work TSCHERSKI's and OBRUCHEV's information on the differences between the orientation of the ancient folds and the modern topographic features. Nevertheless, his theoretical interpretation of these relationships and their usage in the search for trend-lines in Asia were different from those of OBRUCHEV and other Russian geologists. This disagreement will be discussed later in the section "Disjunctive dislocations". This term denotes topographic features that are controlled by faults, displacement along which caused the formation of zones of subsidence. SUESS extensively used this term in the description of the tectonic structure of Siberia.

Unfortunately, SUESS did not accept OBRUCHEV's information about Paleozoic transgressions into the Ancient Vertex and a possibility of the late Silurian folding within it. Those days this information was based mainly on intuition and inference; long-distance stratigraphic correlations based on lithology were a common practice. His incredible intuition in this case misled SUESS. He admitted transgressions of Devonian seas only along the southern periphery of the Ancient Vertex near its junctions with the Altay arcs but he kept the northern part of the Vertex as an uplifted area during the whole of the pre-Cambrian-Paleozoic history. While describing the Vertex, SUESS always talked about Archean or pre-Cambrian rocks. This aspect became crucial for the following evaluation of SUESS' work by Russian geologists. Reading SUESS they got an impression that the Ancient Vertex represented the oldest part of northern Asia to which younger orogenic belts were added. When early Paleozoic marine rocks had been discovered within the Ancient Vertex SUESS' concept faced criticism. It seems to me that this criticism was the main reason that prevented the penetration of SUESS' other ideas into Russian works after 1930. I will touch on this problem later in some detail.

At this point, it is important to realize that TSCHERSKI's paper and first of OBRUCHEV's letters to SUESS established in 1891 a very close connection between Russian geologists and SUESS. We will see the significance of these relationships in the following sections of this paper but here it is time to mention what SUESS thought of the significance of the work of the Russians in Asia:

> *"A compilation of our fragmentary knowledge, however, or any kind of synthesis, was still impossible when the second volume of this work appeared, because those central parts of Asia where the junction of the arcs must be sought, namely Siberia and Mongolia, were almost completely unknown. It is only the latest discoveries of Russian investigators which have now such an attempt possible"* (SUESS, 1908, p. 6).

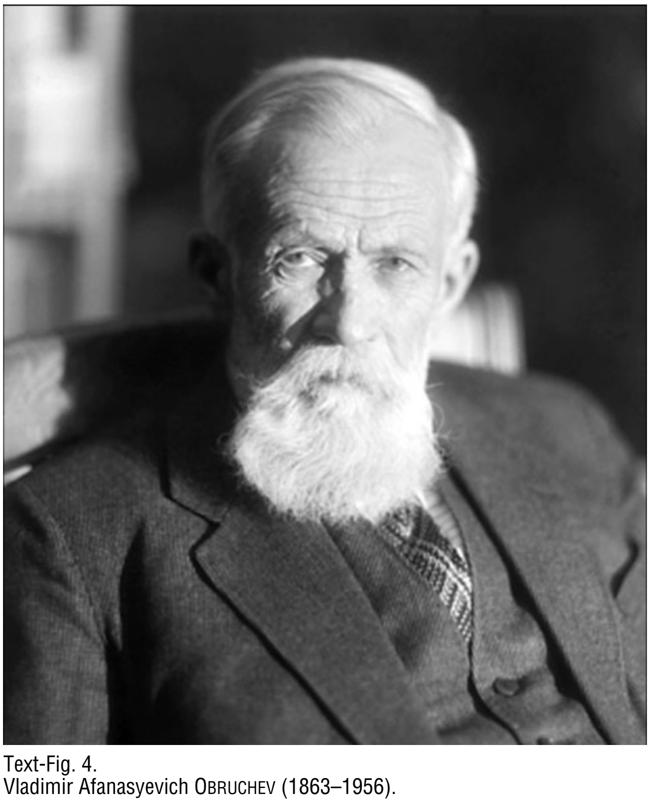
Before proceeding any farther, I need to characterize the key player in this story.

3.2. Vladimir Afanasyevich OBRUCHEV[7] (1863–1956)

It is hardly possible to characterize OBRUCHEV's life and achievements in a short paper. This man lived for 92 years working hard every day (Text-Fig. 4). He published 650 books and papers that in total constitute about 30 000 printed pages (MURZAYEV et al., 1959; OBRUCHEV & FRADKIN, 1947). In Asia, he walked for a total of 30 000 km (so he may be said to have published a page per kilometre!), he mapped 83 000 km^2 in Transbaikalia and 36 000 km^2 in Junggar region (MURZAYEV et al., 1959; Fig. 4).

OBRUCHEV was born in 1863 in a small estate in the Tver province of central Russia. His farther was an officer who participated in the Crimean war in 1854–1856. OBRUCHEV's mother, Polina Karlovna GERTNER, was of German origin

[7] This section is compiled from data provided by MURZAYEV et al. (1959) and PAVLOVSKY (1958).



Text-Fig. 4.
Vladimir Afanasyevich OBRUCHEV (1863–1956).

and because of her OBRUCHEV was fluent in German and French since his childhood. Later he also learned English. Already in a high school, OBRUCHEV acquired an interest in natural sciences and dreamt about traveling. However, he started his university education in the St. Petersburg Technological Institute in 1881.

Studies of mechanics and chemistry did not satisfy OBRUCHEV and in the same year he moved to the Mining Institute in St. Petersburg, which in those days was the best place to obtain a geological education in Russia. OBRUCHEV's teachers were I.V. MUSHKETOV, A.P. KARPINSKY, Gennadii Danilovich ROMANOVSKY (1830–1906). These names are repeatedly cited in "The Face of the Earth". After the death of OBRUCHEV's farther, his family experienced financial difficulties. To support OBRUCHEV, MUSHKETOV suggested to him to translate papers by foreign authors for publication in Russian geological and geographical journals. He gave him for the translation the first volume of VON RICHTHOFEN's "China" and work on this translation had forever fastened OBRUCHEV to Central Asia.

After graduation from the Mining Institute in 1886, OBRUCHEV and his classmate Karl Ivanovich BOGDANOWICH (1864–1947), another great Asian explorer who was also frequently cited by SUESS, eagerly accepted MUSHKETOV's suggestion to study the Karakum desert and the lower reaches of the Amu Darya River. Their future study was relevant to the maintenance of a newly built Trans-Caspian railroad connecting Tashkent and Krasnovodsk. There, one of OBRUCHEV's lifetime topics of research – the origin of loess – started. The interest in the problem of loess was inspired by VON RICHTHOFEN's book on China (1877). OBRUCHEV has disproved the common idea that loess covers large areas in Mongolia and showed that dry climate and prevailing winds lead to accumulation of loess around the periphery of Central Asia (reference).

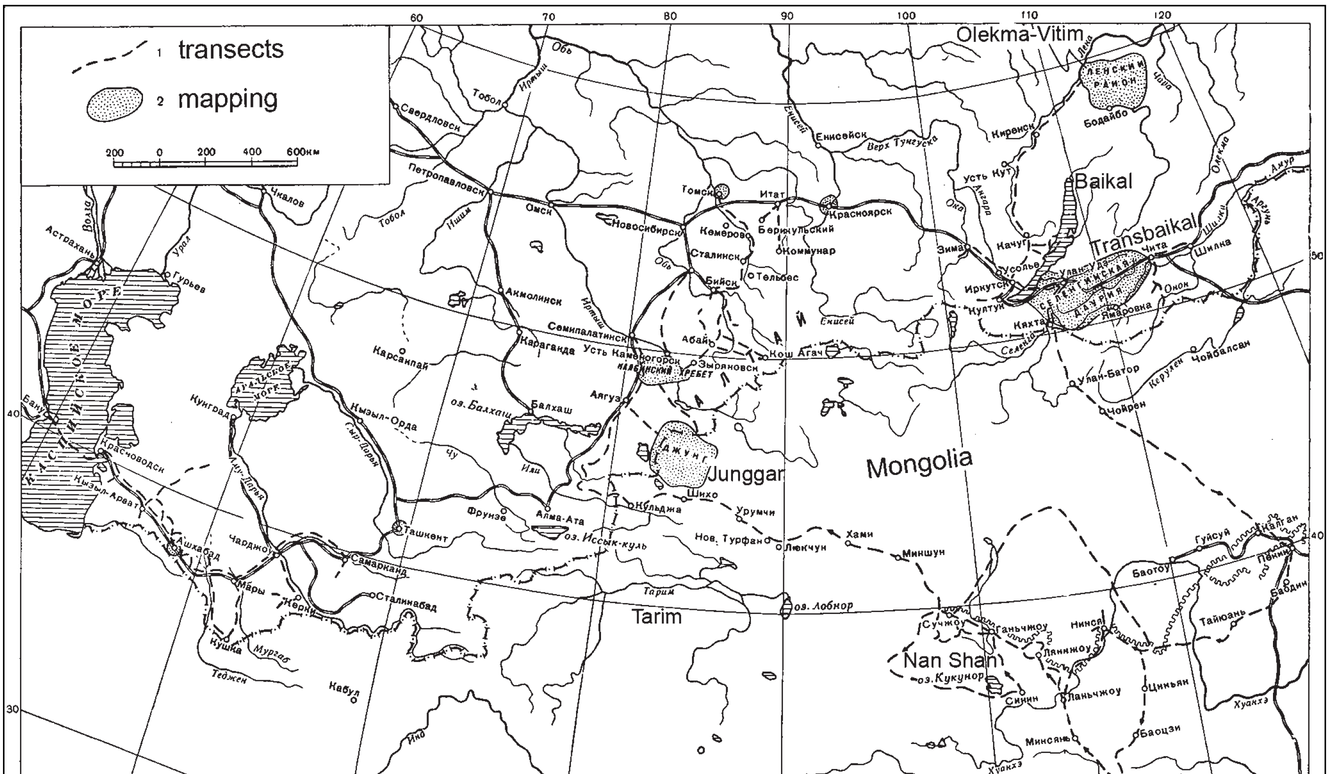
In 1988, OBRUCHEV moved to Irkutsk where he occupied a newly opened position in the Irkutsk Mining Office. In 1888–1892, his primary duties were prospecting and industrial geology, namely checking and evaluating coal mines, gold placers, and quarries for building materials.

Nevertheless, general problems of geology never escaped his attention. He got interested in the extent of the last glaciation in Siberia arguing with such great experts in this matter as Petr Alekseevich KROPOTKIN (1842–1921), Aleksandr Ivanovich VOYEIKOV (1842–1916), and TSCHERSKI. As we see earlier, during this short period of time he was able to learn regional geology to the extent to be able to give in 1892 very valuable advice to SUESS that concerned the geology of the whole of Siberia.

In May 1892, the Russian Geographic Society suggested OBRUCHEV to participate in a big expedition to Mongolia and China. G.N. POTANIN – his name was also frequent in SUESS' citations – was appointed as the leader of the expedition, but OBRUCHEV had to work in accord with a special program worked out by I.V. MUSHKETOV. The expedition lasted till October 1894 and its results were of enormous significance. These achievements must be judged taking into consideration the hardships during the expedition. At average, OBRUCHEV covered 30 km per day making topographic, geodetic, and geological observations. At night he processed data, wrote reports and papers, letters to colleagues including SUESS. This schedule seems tolerable if a researcher has assistants and other servants.

However, circumstances were such that in 1894 OBRUCHEV dismissed the last Russian Cossack and was left alone among local people knowing few words in Chinese and Mongolian. Nevertheless, during and shortly after the expedition OBRUCHEV published an extensive report (OBRUCHEV, 1901) and numerous papers that had made him known to the international geological community.

After the expedition to Central Asia, OBRUCHEV worked in the Transbaikal region where he investigated the disjunctive dislocations. In summer 1905, 1906, and 1909, he conducted field studies of the Junggar region of Northwestern



Text-Fig. 5.
OBRUCHEV'S travels in Asia (modified after MURZAYEV, et al., 1959).

China. As OBRUCHEV recalled these expeditions were inspired by discussions with SUESS in 1899 and 1900 who told him:

"Nothing is known about this part of Central Asia. Mountain ranges are indicated in maps but nobody can tell whether they belong to the Altay or to the Tien Shan system. These two tremendous mountain systems join each other there. A Russian expedition should be sent there. It is not difficult to reach this place because it is close to your boundary with China" (MURZAYEV et al., 1959, p. 206)

The correspondence between SUESS and OBRUCHEV shows that OBRUCHEV regularly informed SUESS about preliminary results of his expeditions. As OBRUCHEV himself says (OBRUCHEV, 1960b) five main scientific problems occupied him during his long and productive live:

1) Origin of loess: After RICHTHOFEN's work people believed that most of Central Asia was covered by loess. OBRUCHEV has proved that Mongolia and large parts of northern China are not covered by loess. He came to the conclusion that prevailing winds removed fine-grained components from the Central Asian deserts and redeposited them at the periphery of the region. This is the main mechanism of loess formation according to OBRUCHEV.
2) Glaciation of Siberia: At the end of the 19th century geologists and geographers believed that sheet glaciers could not be formed in Siberia because of the excessively dry climate of the region. OBRUCHEV has developed the opposite theory and worked on determination of extent and timing of glaciation in Siberia. In this, as we now know, he was mistaken.
3) Tectonics of Siberia. This subject is too wide to encapsulate in a few sentences here and we will elucidate some of OBRUCHEV's achievements in the following sections of the present paper. I just mention here that OBRUCHEV introduced the term "neotectonics" in 1948 denoting by it the study of structures that were formed because of the youngest deformation at the end of Tertiary and in the Quaternary (MURZAYEV et al., 1959).
4) Mining geology and especially gold mineralization.
5) The Ancient Vertex of Asia: Naming of this topic is remarkable. A man whose fame and glory are enormous, listed this subject among the five problems that had determined his lifetime scientific interests. The concept of the Ancient Vertex is the core of SUESS' understanding of the structure and evolution of Asia. Thus, listing this topic OBRUCHEV tells us how close the scientific interests of SUESS and OBRUCHEV were and how complementary their works became. SUESS acknowledged this point several times in the third volume of "The Face of the Earth". On February 7th, 1902 SUESS wrote to OBRUCHEV:

"Russia pays such a great role in my book that I really do not know how to thank you. Recently papers published the news that the St. Petersburg Academy of Sciences had elected me as an honorary member and today they inform that the Geographic Society has awarded me a gold medal. This is absolutely exceptional and pleases me very much. However the main point is your participation in the solution of the main problems. That is especially true concerning the Ancient Vertex and the Amur region" (OBRUCHEV, 1964, p. 271).

4. SUESS and the Other Russian Geologists

Relationships between SUESS and many Russian geologists are self evident from the third volume of "The Face of the Earth" where one can find numerous citations, references to personal communications, and reproductions of figures, some of which Suess received right from the field. Letters from SUESS to OBRUCHEV elucidate additional details some of which are of scientific interest but in large they characterize both the personality of the great Austrian master and his dear Russian friends.

4.1. Exchange of Publications

Starting with 1893, SUESS sent publications of the Imperial Academy of Sciences in Vienna to Tomsk and Irkutsk on the regular basis. Alexandr Petrovich KARPINSKY, the director of the Geological Committee of Russia sent SUESS publications of his institution and the Proceedings of geological work along the Transsiberian Rail Road.

4.2. Fossils Determinations

In 1893, SUESS informed OBRUCHEV that he had just received a collection of Kun Lun fossils from BOGDANVICH. OBRUCHEV, A.P. GERASIMOV (1869–1942), and A.E. GEDROITS (1848–1909) also sent their collections of fossils to Vienna and SUESS worked with them either himself or tried to find better specialists. The processing of Russian collections did not stop even after the arrival to Vienna of a complete collection of fossils gathered by the Indian Geological Committee in the High Himalaya. Perhaps, SUESS was eventually overtaxed with the working of these collections, because in one letter, SUESS suggested OBRUCHEV to send fossils to Russian specialists who, according to SUESS' opinion, were equally good.

Knowing about OBRUCHEV's successful expedition to the Nan Shan, SUESS tried to change a plan of a future expedition organized by FUTTERER to the eastern Tien Shan, Turfan region, and Beijing. He suggested to FUTTERER to turn to the south from Kashgar and study Triassic rocks of the southern Pamir and afterwards move to Qaidam. The reason was simple – Nan Shan had been studied well enough and could wait. FUTTERER did not accept SUESS' advice. In November 1897, SUESS informed OBRUCHEV about this expedition and suggested to publish data on the Ljuk-tshun Graben and Nan Shan as soon as possible. Thus, SUESS worried about priority of his Russian friend.

4.3. Personal Relationships

Exchange by literature and cooperation in processing of data were supplemented by excellent personal relationships. A.A. INOSTRANTSEV (1998, p. 96) recollects his first trip to Europe in 1871:

"First of all I introduced myself to E. Suess, the eminent Viennese geologist, a man of amiability and kindness, who in contrast to the other foreign geologists was well familiar with scientific works of Russian geologists. … I met there G. Chermak, E. Tietze, K. Diener, D. Stur, and others. I met also M. Neumayer married to a pretty daughter of E. Suess, who possibly had already been invited to the Department of geology in Munich. We exchanged our publications with many of them during the rest of our life. I must confess that the above mentioned geologists, and also those to whom I was not introduced, accepted me and my family so cordially that I would never forget it."

Closer to the end of his life in 1919 INOSTRANTSEV wrote:

"Participation in international geological congresses became more difficult now because my old friend-geologists started quickly to leave the inhabited world. F. Zirkel, G. Credner, A. C. de Lapparent, D. Capellini, E. Suess, E. Mojsisovics, G. Chermak, and E. Kogen have passed away. Of course, instead new people had shown up, however old traditions and my former acquaintance with the great sci-

entists of old times could not be rekindled in the new faces." (INOSTRANTSEV, 1998, p. 178).

4.4. SUESS and the Russian Language

We have seen that while working on Asia SUESS communicated with Russian geologists and followed all new publications by Russians. In May 1986, SUESS informed OBRUCHEV that he had found a young men who knew Russian and German and who helped him every day in reading the Russian edition of RITTER's Asia[8] (OBRUCHEV, 1964). In June 1898, SUESS informed that:

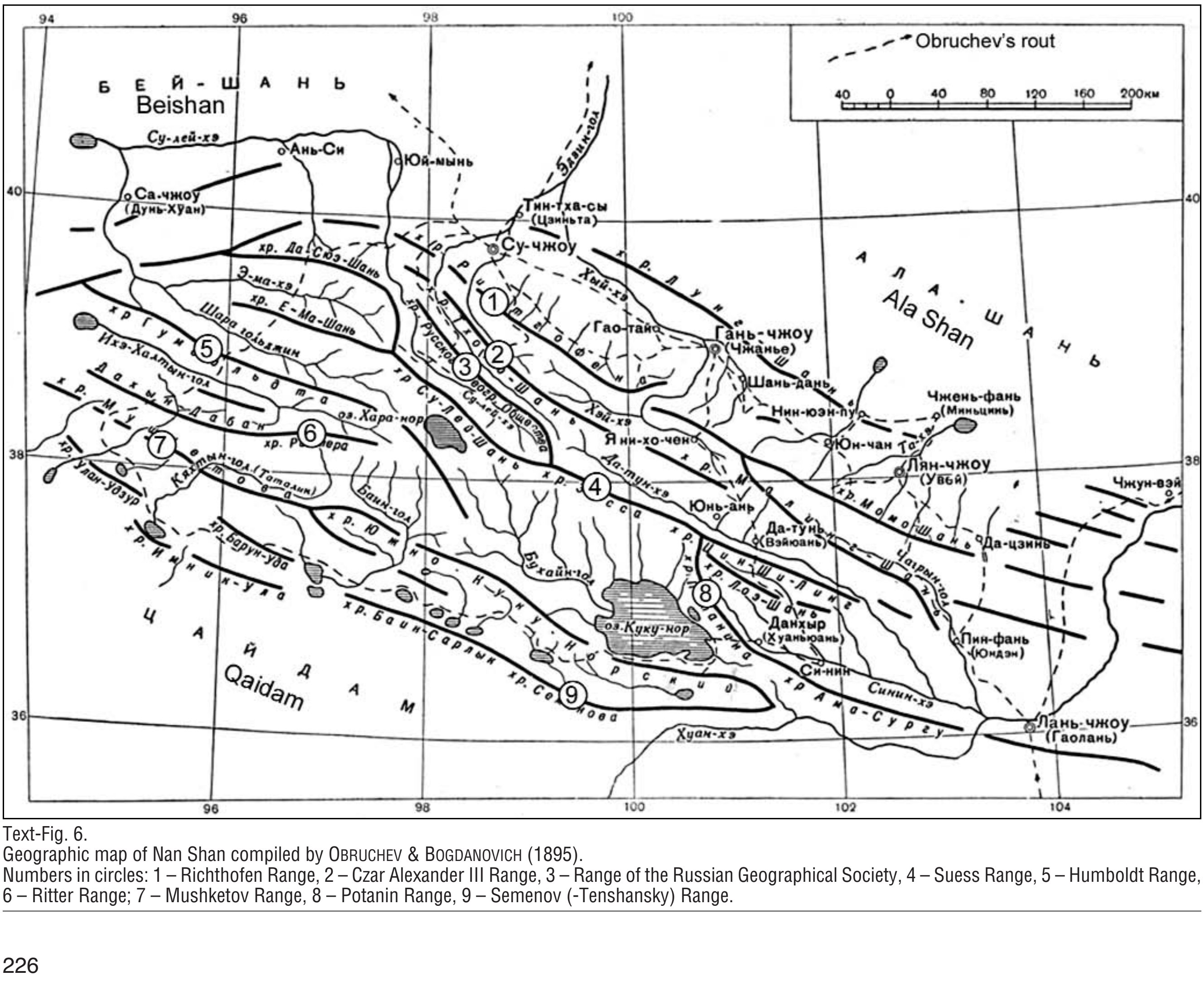
> *"Last month, I read all the Russian literature that was published between 1850 and 1860. This was an uneasy task because of my poor knowledge of your language though I had learned it to some extent. Now my work will proceed faster but I am not sure that I will finish it by the end of the year"* (OBRUCHEV, 1964, p. 254).

Despite this modest self-evaluation SUESS' command of Russian language was incredible (see also his student NOPSCA's remark in NOPCSA, 2001, p. 8–9). He was familiar with all the important works most of which were not short papers but thick, true tomes. For instance OBRUCHEV's two volumes of Central Asia constitute 1350 printed pages and SUESS was not lost in them. Almost all the critical discoveries reported in the large Russian books were included in his third volume.

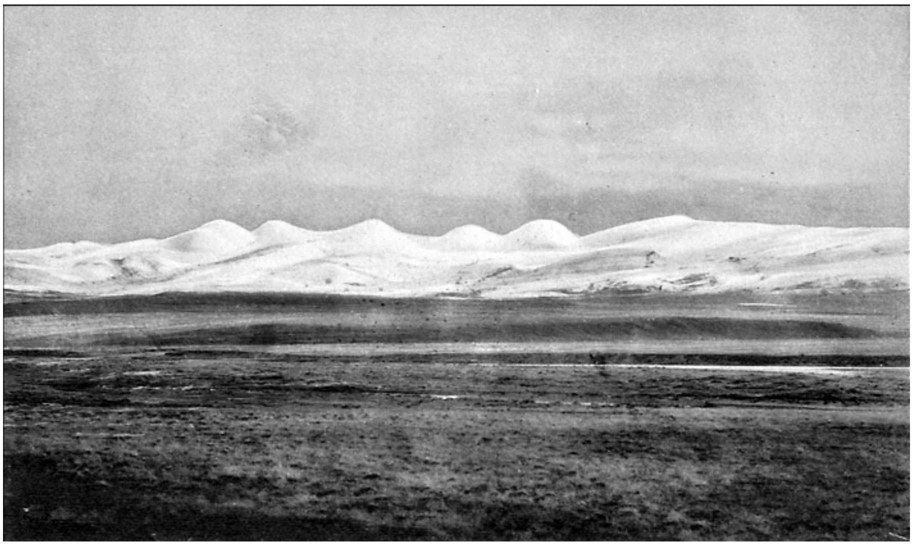
[8] The Russian Geographic Society initiated translation of RITTER'S "Asia" in 1851. At least 5 volumes were published with extensive additions that became possible after Russian and other expeditions in Central Asia. SEMENOV-TIENSHANSKY, a former student of RITTER'S, was the translator, editor, and author of the additions to these volumes. In fact some of his original data he published as additions to Ritter. This explains the way SUESS read the Russian edition of RITTER'S Asia with the Russian translater.

4.5. Joint Publication

Based on Chinese sources RICHTHOFEN (1877[1971]) inferred that a Tertiary sea covered a considerable part of Central Asia in which red clay and sandstone were deposited. These marine deposits are overlain by a thick pile of loess. This sea got the Chinese name Khan-Khai (Dry Sea). The Kan-Khai concept was a very popular hypothesis. Many travelers in Central Asia accepted it and developed their own concepts about the gradual dessication of Central Asia (e.g. MUSHKETOV, 1886). OBRUCHEV was a follower of this concept though at the very beginning of his expedition in Central Asia he had discovered that loess was absent in Central Asia but he believed that the underlying gypsum bearing red shales and sandstones were deposited in the Khan-Khai sea. In 1892, in the eastern part of southern Mongolia, OBRUCHEV found fragments of bones and teeth in these rocks and at the beginning of 1899 sent them to SUESS thinking that they were fragments of fishes! SUESS had immediately replied indicating that the fragments in fact belonged to a Rhinoceros, that the surrounding sediments were medial Tertiary in age and freshwater in character, and that the importance of this finding was enormous. Several SUESS letters written in spring 1899 show a hot discussion between these two great scholars. SUESS tried to convince OBRUCHEV that fragments of Rhinoceros indicated the absence of the Khan-Kai sea, OBRUCHEV resisted, putting forward arguments



Text-Fig. 6.
Geographic map of Nan Shan compiled by OBRUCHEV & BOGDANOVICH (1895).
Numbers in circles: 1 – Richthofen Range, 2 – Czar Alexander III Range, 3 – Range of the Russian Geographical Society, 4 – Suess Range, 5 – Humboldt Range, 6 – Ritter Range; 7 – Mushketov Range, 8 – Potanin Range, 9 – Semenov (-Tenshansky) Range.



Text-Fig. 7.
Suess Range.
Photo by V.A. OBRUCHEV (1901).

that the precipitation of gypsum from fresh water was hardly possible. Finally SUESS had convinced OBRUCHEV and a joint publication appeared in the Proceedings of the Mineralogical Society (SUESS, 1899). In the title SUESS is indicated the author and OBRUCHEV as a contributor. However, examining this paper we see that SUESS' part is separated from OBRUCHEV's one and Suess' part is a pure paleontological description. SUESS left for OBRUCHEV all principal conclusions. How friendly the relationships of these men were!

4.6. The Suess Range

In 1893 OBRUCHEV gave SUESS' name to one of the ridges in the Nan Shan (Text-Fig. 6), now known under the name of Da Tong Shan (according to the Zhonghua Renmin Gongheguo Fen Sheng Dituji, 1983 edition). Text-Fig. 7 shows OBRUCHEV's photo of the eastern part of the Suess Range. Its distinct topographic feature is evident. He also named many other ridges in this mountain system.

These names as well as many other geographic names given by European geographers and geologists circulated in literature at least till 1955[9] (OBRUCHEV, 1960a). In the forties and the fifties of the twentieth century, especially during the good relationships between the Soviet Union and the Peoples' Republic of China, there was a chance that all these names might be accepted as official names. For instance, S. CHU from the National Geological Institute of Academy of Sciences of China used OBRUCHEV's names of ridges in the Nan Shan (CHU, 1937).

However, the subsequent deterioration of relationships between these two countries led us to the present day state of affairs when reading classical geographers and geologists is hardly possible without access to old maps and atlases because of the extensive alterations of the geographical names.

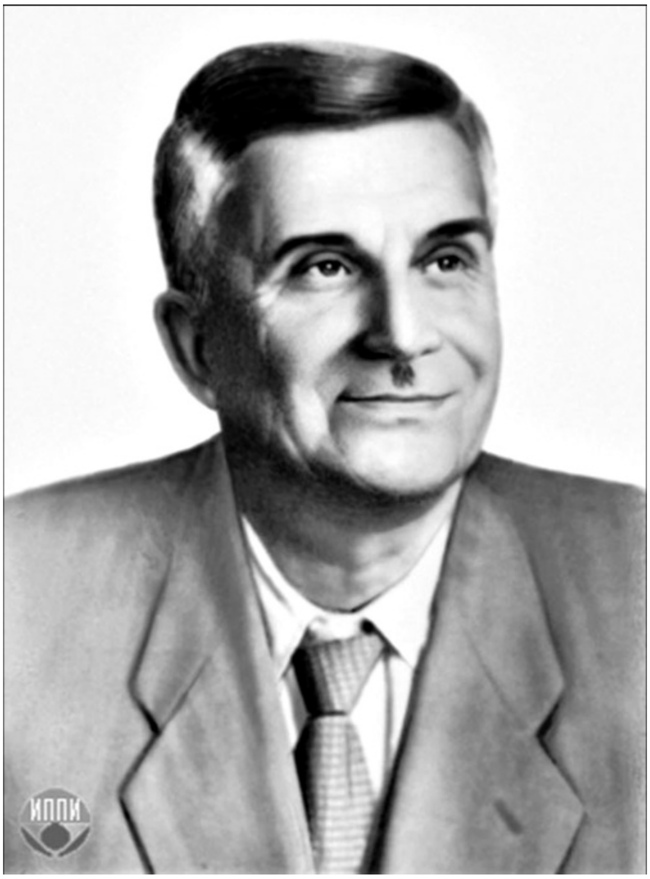
SUESS' modesty prevented him from using the name Suess Range in his description of the Nan Shan. He used all other names suggested by OBRUCHEV, but the Suess Range appears in the text as a featureless Forth Range.

5. Decline of Interest in SUESS in the Russian Geological Literature

The history of ideas on the determination of the Russian and Siberian cratons has two important aspects. First, it illustrates how the discussion about the Ancient Vertex of Asia, a subject that was never properly understood, gradually deteriorated from being a principal question of tectonics – the mechanism of continental growth – to a question of local importance such as the age of folding in the northern part of the Transbaikal region. Secondly, this history perhaps explains why SUESS' name gradually disappeared from lists of references in papers of Russian geologists. I will consider two stories.

The first one concerns the establishment of the Siberian craton in which SUESS was unjustly criticized. The second story concerns the Russian craton in which SUESS was not criticized directly but ideas of other researchers whose scientific philosophy was in accord with SUESS but had been considered wrong.

Both stories happened in the 30s and in both cases the criticism emanated from Nikolay Sergeevich SHATSKY (Text-Fig. 8). By this time SHATSKY was a vice-director of the Geological Institute of the Academy of Sciences of the USSR. Together with Andrej Dimitrievich ARKHANGELSKY (1879–1940) he is considered as a co-founder of the tectonic school in the USSR. This school was and is still highly respected. Many publications by ARKHANGELSKY, SHATSKY or their closest followers determined the development of Russian tectonic researches for many years.



Text-Fig. 8.
Nikolai Sergeevich SHATSKY (1895–1960).

[9] They are also used in Sven HEDIN'S 1966 Atlas of Central Asia (HEDIN, 1966) and its extensive index (FARQUHAR et al., 1967).

5.1. The Siberian Craton

The vast majority of Russian papers dealing with the Siberian craton usually cites a famous SHATSKY paper published in 1932 as a primary source in the establishment of this craton. This paper was reprinted in 1964 in the collection of SHATSKY's selected publications (SHATSKY, 1964a) and this widely used version is used also here as a source for quotations. In this section, I want to demonstrate two important issues. First, SHATSKY misunderstood the role that SUESS played in establishing the Siberian craton. Second, SHATSKY criticized OBRUCHEV, who supported and developed SUESS' idea during his whole life (MURZAYEV et al., 1959), as concerns the wrong interpretation of the age of the last folding in the Ancient Vertex. In doing so SHATSKY focused his as well as all subsequent researchers' attention on the age of folding within the Vertex but not on the tectonic significance of this tectonic unit.

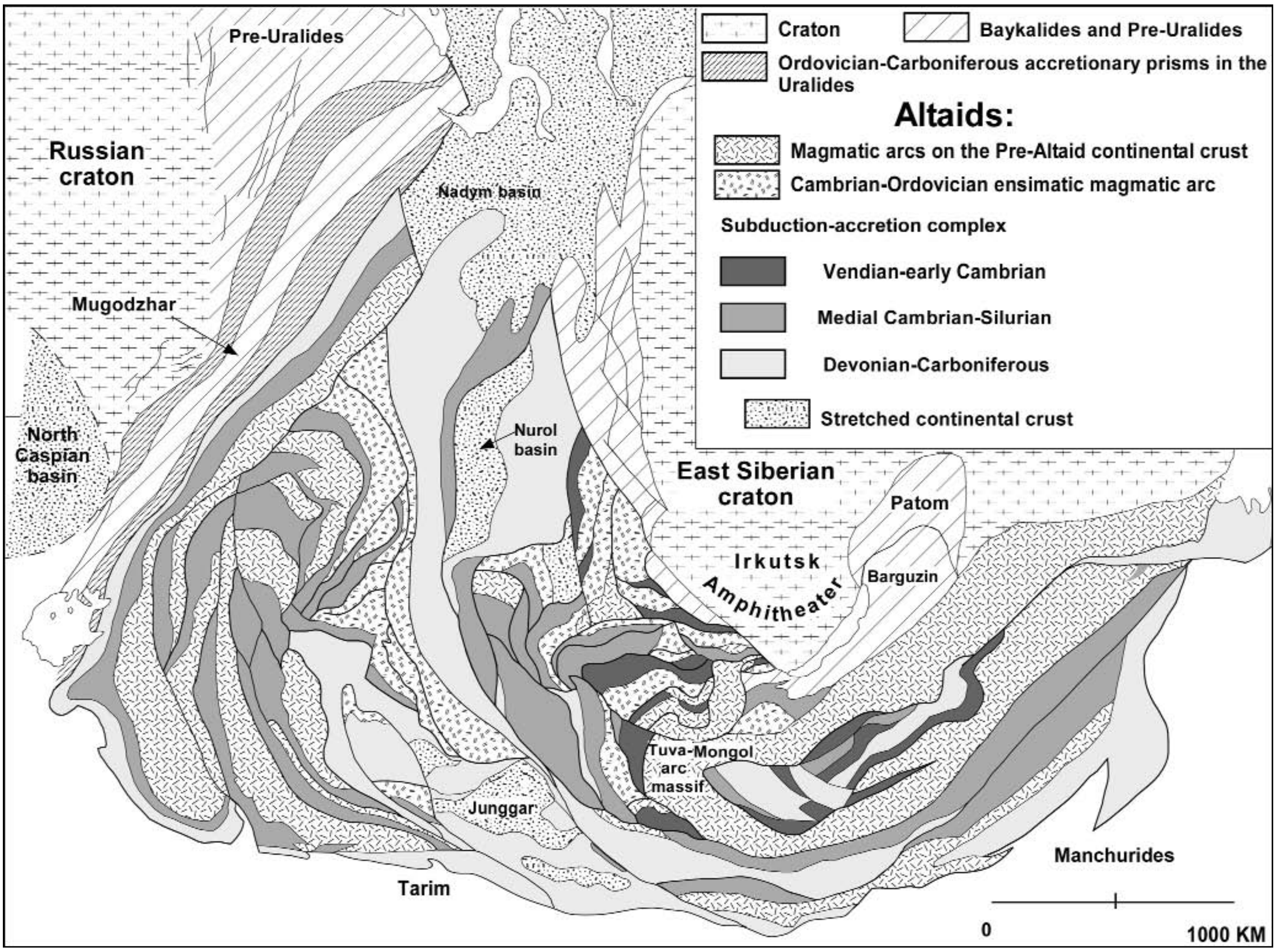
Indeed, today our understanding of the region that belongs to the Ancient Vertex is very different from that at the end of the 19th – beginning of the 20th centuries.

The main part of the Vertex consists of the Barguzin microcontinent and the Tuva-Mongol arc massif the basement of which is made of Precambrian rocks (Text-Fig. 9). Skipping most of the Precambrian history, which is still poorly studied, we know now that the tectonic history of the Vertex (Baikal-Patom region) as such started with the Neoproterozoic Baikalian orogeny. This orogeny was a result of the collision of the Barguzin microcontinent with a passive continental margin of Siberia (BERZIN & DOBRETSOV, 1994; ŞENGÖR & NATAL'IN, 1996). Vendian sediments cover the suture between the Siberian craton and the Bargusin microcontinent. After the collision, Early Paleozoic magmatic arcs were developed along the southwestern margin of the microcontinent (BELICHENKO et al., 1988; GORDIENKO, 1987).

The evolution of the Tuva-Mongol arc, which forms a sharp orocline, was characterized by migration of the hinge of the orocline to the west and this migration pushed the Barguzin microcontinent farther to the north (ŞENGÖR & NATAL'IN, 1996). This motion led to the pre-Devonian deformation in the region of the Siberian platform (ŞENGÖR & NATAL'IN, 1996) that was defined by SUESS as the Irkutsk Amphitheater. The external rim and the core of the Tuva-Mongol orocline consist of Vendian to late Paleozoic subduction-accretion complexes that are as young as Triassic in the east (ŞENGÖR et al., 1993; ŞENGÖR & NATAL'IN, 1996). These subduction-accretion complexes are paired with magmatic arc igneous rocks that are superimposed on the Tuva-Mongol massif.

The whole of the region was deformed by Mesozoic strike-slip faulting and by Cainozoic extension. Indeed, the tectonic history is complicated, however, if one tries to put it in one sentence this sentence may look like:

> *"The tectonic history of the Ancient Vertex is the Baikalian amalgamation of the Barguzin microcontinent and the Siberian craton and afterwards the continuous Vendian-Paleozoic growth of the Tuva-Mongol arc attached to the Siberian craton/Barguzin at the expense of the formation of subduction-accretion complexes and additions made by arc*



Text-Fig. 9.
Tectonic map of the Altaids (ŞENGOR & NATAL'IN, 1996).
The Ancient Vertex was shown of SUESS' map. It roughly corresponds to tectonic units that are indicated as Patom (Riphean passive continental margin of the Siberian craton), Barguzin (Proterozoic Barguzin microcontinent), and northern limb of the orocline made of the Precambrian Tuva Mongol massif.

magmatism during the late Precambrian-early Mesozoic." (ŞENGÖR & NATAL'IN, 1996; ŞENGÖR et al., 1993).

In 1932 SHATSKY defined two groups of ideas concerning the nature and boundaries of the Siberian platform. The first group is represented by the ideas of TSCHERSKI, SUESS, and OBRUCHEV. Acknowledging that SUESS has wholly accepted TSCHERSKI's ideas on the tectonic structure and the evolution of Northern Asia SHATSKY writes, without giving any reference to any of SUESS' writings and possibly even without having ever read them:

> *"Asiatic edifices of E. Suess represent mainly a folded region, different segments of which were constructed during different episodes of the post-Precambrian history of the Earth's crust. Besides, this region includes a series of stable Precambrian massifs. In Northern Asia, one of these massifs is an ancient pre-Paleozoic platform – Angara Land – that completely embraces the highland plains of Tscherski. According to Suess, this platform constitutes the West Siberian lowland in its large parts* [This claim by Shatsky is entirely incorrect and that is why confusing for the modern reader]. *In the south, closer to Baikal and the Eastern Sayan, the Angaran continent forms folded mountains rising as an amphitheater over the northern platform. Tscherski established this folded arc that was later called the Irkutsk amphitheater by Suess.*
> *Immediately to the south of the amphitheater, almost in the middle of Asia is the main area of Asiatic edifices defined by Suess – the Ancient Vertex – that wholly coincides with High Plateau of I.D. Tscherski. This coincidence is not only morphologic or orographic. Suess depicts the history of this region exactly like Tscherski did: the subsidence of the Irkutsk amphitheater happened already in the Precambrian times and ancient Paleozoic seas that covered the* [Siberian] *platform invaded the Irkutsk amphitheater too but they did not penetrate the Ancient Vertex that was a shore of transgressing seas"* (SHATSKY, 1964a, p. 198).

Then, SHATSKY says that OBRUCHEV developed TSCHERSKI's and SUESS' ideas on the Ancient Vertex. He reproduces OBRUCHEV's tectonic map in which the pattern of the Vertex covers the whole of the Aldan shield, the Anabar shield, Taymyr Peninsular, a part of the Bureya massif, and some regions in Altay. SHATSKY stresses that according to OBRUCHEV seas never covered the Vertex since the Precambrian (Eozoic times) and the Vertex is a tectonic equivalent of the first order continental blocks according to VON BUBNOFF's classification[10], that is the Vertex is equal to the Baltic or Canadian shields.

At this point, it is important to indicate several misunderstandings or distortions of SUESS' original ideas by SHATSKY. First, SUESS made a very clear tectonic distinction between the West Siberian Plain that is known now as the West Siberian Basin and the East Siberian Tableland that is known now as the Siberian craton.

Secondly, SUESS never said that the Precambrian basement underlies the West Siberian basin. SUESS indicated that Kirgiz and Uralian folds plunge beneath the Mesozoic cover of the West Siberian Plain. This means that Paleozoic rocks form the basement of the West Siberia Plain. SUESS did infer a connection of the Ancient Vertex and the Russian platform but he never specified where this connection lies. It means that it could be beneath the West Siberian plane or somewhere farther to the north. Suess was very specific saying that the basement of the West Siberian plane was covered by Cretaceous and younger deposits.

Thirdly, according to SUESS the boundary between the West Siberian Plain and the east Siberian tableland coincides with the Yenisey River and this boundary is represented by a fault. This is exactly how this boundary is now accepted on many maps and figures in recent publications (KORONOVSKY, 1984; MILANOVSKY, 1987; ZONENSHAIN et al., 1990). On the other hand, SHATSKY (1964a) has shown the western boundary of the craton far to the west, near the Ob River. Paleozoic folded rocks and ophiolites have been penetrated by wells to the east of SHATSKY's boundary (SURKOV, 1986; SURKOV & JERO, 1981), clearly showing that SUESS' boundary is right and SHATSKY's later "correction" is wrong.

Forthly, according to SUESS the Angara-Land is a continent in accord with the geographic meaning of this term (we would today call it a „super-continent"). This continent is defined as a counterpart of the Gondwana-Land as a certain high standing part of Asia that is characterized by the presence of the Angara Series – coal-bearing deposits late Paleozoic-early Mesozoic in age. SUESS described the Angara Series in many places outside of his East Siberian Tableland thus demonstrating that the tectonic nature of the basement and its age are irrelevant for the definition of the Angara-Land. In our previous publications my colleague A.M.C. Şengör and I have consistently called the Siberian craton „Angara Craton". This was done to avoid falling into the trap that SHATKSY fell: Not all of Siberia is a craton. But then neither was all of Angara-Land a craton. SUESS originally called the cratonic entity bound by the Yenisey and the Lena Rivers the East Siberian Table-land. This is a designation that has no ambiguities and we think it is advisable to return to it. We shall henceforth refer to what we used to call the Angara Craton, the East Siberian Craton (Text-Fig. 9).

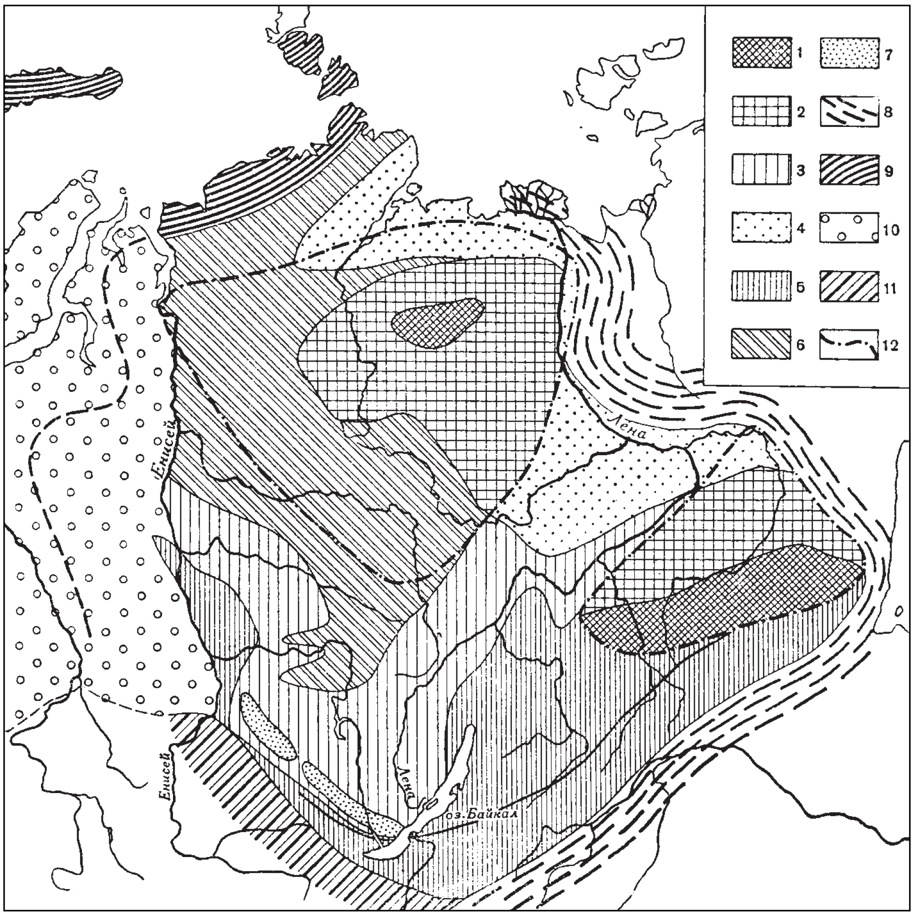
Fifthly, we have seen early that originally OBRUCHEV inferred the invasion of the early Paleozoic seas into the Ancient Vertex and that late Silurian deformation affected it (OBRUCHEV, 1964). Later, he changed his mind and viewed the Ancient Vertex as a region that was not involved in the orogenic development since the Paleozoic. He ignored the interpretations based on new discoveries of Paleozoic and Mesozoic fossils within strongly deformed rocks occurring inside the Ancient Vertex. This behavior perhaps irritated his colleagues who gave him a mocking nickname "super classic" (INGIREV, 1948). In 1946, upon the request of the Geographical Society, OBRUCHEV published his autobiography in which he wrote that SUESS had defined the Ancient Vertex as the oldest part of Asia to which new portions of crust were added. He continues:

> *"I defend Suess' hypothesis, excluding in accord with the new data Eastern Sayan from the Ancient Vertex, and think that the problem may be resolved only by the discovery of strongly deformed marine Cambrian-Silurian rocks within the Ancient Vertex, which will prove that the Vertex was covered by old Paleozoic seas and was affected later by strong deformation of the Caledonian cycle"* (OBRUCHEV, 1960b. p. 12).

As we see in the 30's OBRUCHEV's ideas started to conflict with new data.

Presenting the ideas of the second group on the nature of the Siberian craton SHATSKY started with the detailed description of DE LAUNAY's ideas published in 1913 (DE LAUNAY, 1913) although they were published for the first time in 1911 (DE LAUNAY, 1911). The main difference between DE LAUNAY and SUESS, as many geologists accept it, is that DE LAUNAY interprets the structure of Asia as a closure of the geosyncline between primary massifs: Angarian and Gondwanian (OBRUCHEV, 1937). A long quotation from DE LAUNAY (1913) and a tectonic map reprinted from DE LAUNAY in SHATSKY's paper explain the structure of

10) Although SHATSKY provides no reference to VON BUBNOFF, the paper he means is VON BUBNOFF (1923). See especially the table showing the nature of various blocks on pp. 30 and 31.



Text-Fig. 10.
SHATSKY'S (1932) tectonic map of the Siberian craton (SHATSKY, 1964).
Note a wide zone of the early Paleozoic folding in the Irkutsk Amphitheater and the position of the western boundary of the craton in the middle of the West Siberian Basin.
1 – gneiss massifs constituting the North Siberian and Aldan (in the south) blocks, 2 – early Paleozoic margins of these blocks, 3 – Lena-Yenisey Cembrian-Silurian zone, 4 – Lena-Vilyui and Khatanga basins, 5 – Baikal folded zone, 6 – Tunguss basin, 7 – Irkutsk and Kan-Yenisei Mesozoic basins, 8 – zone of marginal Alpine folding, 9 – zone of Variscan folding, 10- West Siberian lowland, 11 – Caledonian zone of Eastern Sayan, 12 – boundaries of the North Siberian and Aldan blocks.

Asia to the south of the Siberian craton. The Siberian ancient massif (the platform) is surrounded by the Caledonian, Hercynian, and Alpine zones in a roughly concentric pattern. From the quotation we learn that the Siberian block grew by the consecutive addition of younger and younger zones, the youngest of which is the Himalaya. To my opinion, all the best what SHATSKY found in De Launay is essentially what one can easily find in SUESS and what is in fact the essence of SUESS' concept. Not noticing that SUESS' ideas had been rehashed and repeating the serious mistakes in DE LAUNAY's map which had been already noticed by OBRUCHEV (1937), SHATSKY highly prizes DE LAUNAY and adds that his view on Siberian structure has been specified and developed by TETYAEV (1916) and BORISYAK (1923). Tetyaev had defended the Caledonian age of folding within the Ancient Vertex and interpreted the metamorphic rocks of the Transbaikal region as a huge south-vergent nappe.

On his own map SHATSKY shows a zone of Baikalian folding (Text-Fig. 10). In the text he indicates that in this zone Cambrian rocks are metamorphosed and strongly folded. In fact he does not present direct data on the Cambrian age of these rocks and only accepts suggestions made by Tetyaev and other researches. It was shown later that the majority of these rocks are late Precambrian in age. SHATSKY correlates the zone of Baikailan folding with folded rocks of the Yenisey Horst. The critical point in this comparison was the strong deformation of the Cambrian rocks. As a result, a large part of the Ancient Vertex was interpreted by SHATSKY as a zone of Caledonian folding that had been added to the Siberian craton.

If SHATSKY's and SUESS' ideas are compared, SHATSKY is closer to our modern view on the age of deformation in the region however his achievement is not based on the establishing of the critical data set but it is based on the reinterpretation of data. It is not bad, but any reinterpretation is valuable when it leads to a new explanation of a bigger problem. Concerning the growth of the Asian continent, SHATSKY just repeats using different terminology SUESS' discovery made 30 years earlier. SHATSKY considers himself as a follower of De Launay and Borisyak (Borisyak, 1927) however his quotation of Borisyak clearly shows that a summary of Suess' idea exists in it:

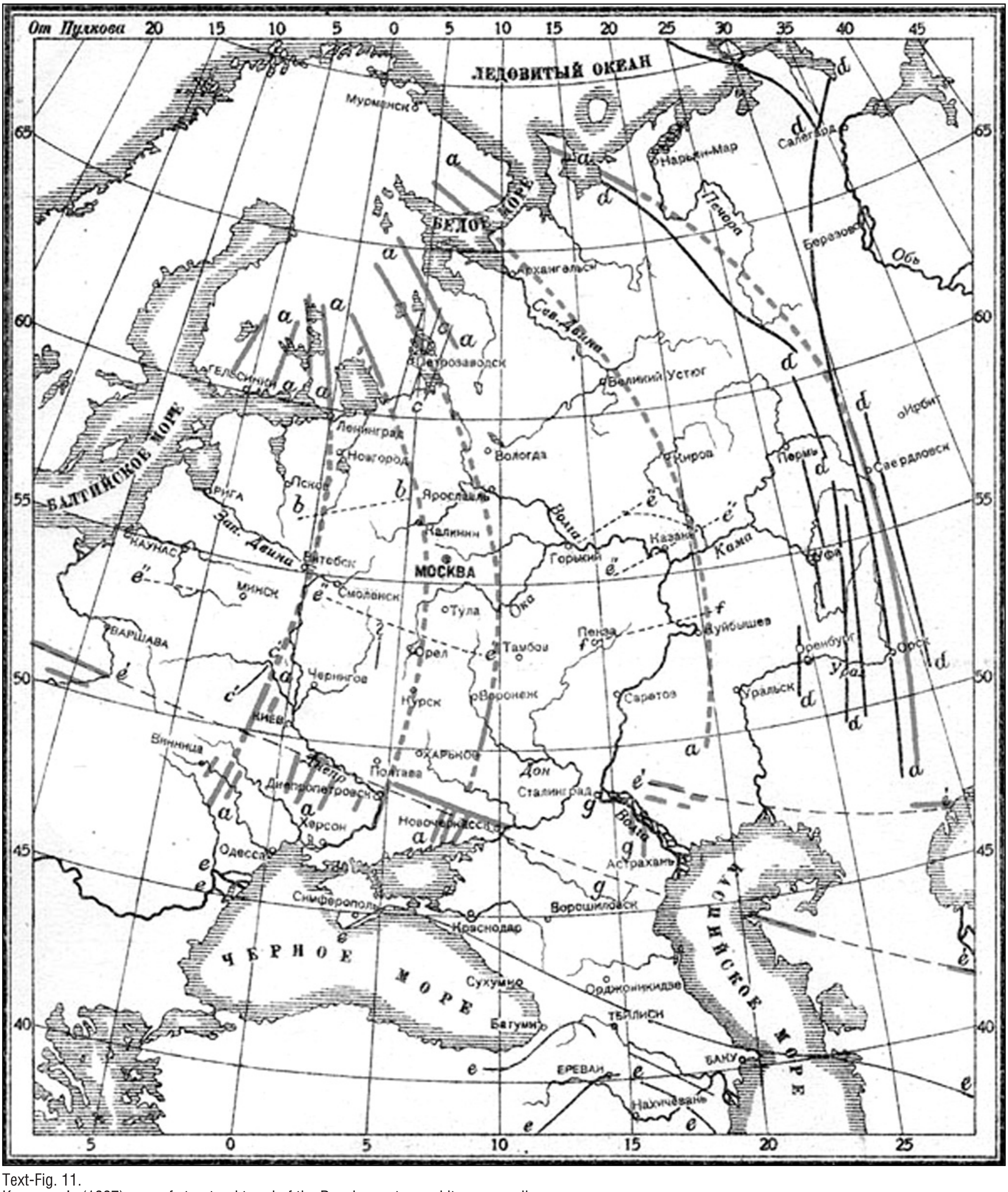
" … in the central part between Yenisey and Lena and farther to the southeast, till the Aldan Valley is reached, is the Siberian Platform, a tableland that consists of gently lying early Paleozoic sediments partly overlain by younger coal-bearing and other sediments. In the south, folded zones adjoin it; first the older, Caledonian (Suess' the Ancient Vertex of Asia), then the newer or Hercynian zone (the Altaids or graywacke zone of Suess). Today these zones are denuded and represent mountainous highland or hilly terranes being converted into the mountains by erosional processes which followed the latest movements along disjunctive dislocations (horst and grabens). In the west, the Siberian platform forms a boundary with the folded (Hercynian) zone that is located between the Yenisey River and the Ural Range and that is hidden beneath the young deposits of the West Siberian Plain. In the northeast, [the Siberian platform] adjoins the folded area of the Northeastern Siberia that is almost completely unknown … " (this quotation is taken from SHATSKY, 1964a, p. 201).

Interestingly, fighting with SUESS using the age of folding or distinction between geosynclinal and cratonic regions SHATSKY changed his mind in 1934. In this year, together with ARKHANGELSKY, he published the first tectonic map of the USSR (ARKHANGELSKY, 1934). On this map, the zone of Baikalian folding is included into the Siberian Precambrian platform. Nothing serious is left of the former disagreements with SUESS that were more apparent than real. Wherever the disagreements were real, in the end SUESS turned out to be right except in the question of the age of the last folding in the Ancient Vertex.

5.2. The Russian Craton

5.2.1. SUESS and KARPINSKY

The term "Russian Platform" was introduced by SUESS (first volume, 1904, pp. 180–183) as a Precambrian block consisting of the Baltic shield, the central part that is covered by the Cambrian and younger sediments, and the southern Russian broken region where Precambrian rocks are exposed. SUESS relied mainly on Aleksandr Pavlovich KARPINSKY's paper (KARPINSKY, 1883) who discussed the same region without giving to it a specific name. Nevertheless KARPINSKY defined the region as a stable area that was very different from zones of folding (plicative zones) and zones of disjunction (subsidence accompanied by faulting). KARPINSKY recognized all the above-mentioned parts of the platform, established structural elements of different order within the platformal cover, and suggested a method of study of the evolution of these structures using paleontology, paleogeography, and facies changes. The Baltic shield and the southern block of high standing Precambrian rocks were interpreted as horsts. Despite the large distance between these horsts their internal structural trends reveal the same north-south direction (KARPINSKY, 1887) (Text-Fig. 11). The structure and the evolution of the sedimentary cover of the central part of the platform



Text-Fig. 11.
KARPINSKY'S (1887) map of structural trend of the Russian craton and its surroundings.
Thick dash lines – trends of Precambrian rocks. Note their continuity beneath the platformal cover. Thick solid lines – Uralian trends. Thin solid and dash lines – Mesozoic trends that were called KARPINSKY lines by SUESS.

was the main target of KARPINSKY's study who dealt with it in a later paper (KARPINSKY, 1894). Paleogeographic maps show that shapes of seas within the Russian craton reveal periodic changes of the pattern of subsidence. Periods of north-south elongation of these seas alternated with periods of east-west elongation of the seas. KARPINSKY inferred that this pattern was controlled by orogenic movements in the Urals and Caucasus. KARPINSKY called the change of the sea patterns oscillatory motions; however, while discussing the paleogeography, he never spoke about uplifts but always about subsidence. Similar to SUESS, KARPINSKY thought that contraction of the Earth was the driving mechanism of deformation.

It seems that SUESS accepted many of KARPINSKY's discoveries. For instance, the north-south trend of Precambrian structures was very clearly shown on KARPINSKY's map (KARPINSKY, 1887, see Fig. 11 herein). In the third volume, SUESS discussed these trends extensively because he used them for the determination of the origin of the Urals. Of course, SUESS used additional data, but the general idea of KARPINSKY had not been significantly changed. On the other hand, KARPINSKY was also considerably influenced by SUESS. In the second edition of the 1894 paper and in additional papers (KARPINSKY, 1919a,b; 1939) KARPINSKY enthusiastically accepted SUESS' concept on the evolution of Asia. He assigned the Urals to the Altaids and inferred that oscillatory motions within the Russian platform were a consequence of the propagation of the Altaid waves into cratonic interiors. The famous KARPINSKY Lines located in the southern part of the Russian Platform (Text-Fig. 11) have also been interpreted as a result of the Altaid evolution. This time waves propagated from the south. SUESS' and KARPINSKY's ideas on the structure and evolution of the Russian craton are of great interest. Today they lie in the cores of many modern concepts. They may stimulate new studies. For instance, if the Caucasus/Urals influence on the evolution of the sedimentary cover of the Russian craton was so evident already in KARPINSKY's time, why the evolution of the European Hercynides has not played a similar role? What is the difference between the suture zones in the Urals and the Trans-European suture zone that evolved

> *" ... through the polyphase Caledonian, Variscan and Alpine orogenic cycles" ...* (PHARAOH, 1999)?

Why did collisions or other tectonic events along the southwestern side of the Russian craton not provoke the oscillation motions in the craton interior? This is a good target for future research.

5.2.2. ARKHANGELSY and SHATSKY on SUESS' Priority in the Definition of the Russian Craton

Some of Russian geologists acknowledged SUESS' priority (e.g. MAZAROVICH, 1938) in the establishment and especially in the naming of the Russian Platform but others tried to blur the history of ideas. This story is not too significant, but it is of some interest. In a series of papers dealing with the Russian platform published between 1937 and 1960, SHATSKY (1964b) usually describes the history of ideas but never mentions SUESS' priority. Exception is his little book about MURCHISON (SHATSKY, 1941). Nevertheless he uses the term suggested by SUESS and the terms "the East-European Plate" and "the East-European Platform" suggested by ARKHANGELSKY interchangeably in these papers. Introducing the term "the East-European Plate", ARKHANGELSKY (1932) retains everything what Suess had included in the meaning of the Russian Platform (age, subdivisions, boundaries). The motivations for the change of the name are expressed as follows:

> *"Concerning the term Russian Plate it must be completely cast away despite of its priority because on the one hand the word "Russian" in modern conditions is hardly applicable to the whole of the territory, and on the other hand, which is the principal reason, the notation the Russian Platform has never encompassed the Baltic shield"* (ARKHANGELSKY, 1932).

The first objection is not of importance but the second reason is blatantly wrong because SUESS considered the Baltic shield as well as the crystalline rocks of the southern Russia as parts of the Russian platform knowing the continuity of the Precambrian trends established by KARPINSKY (SUESS, 1904, pp. 180–183). SHATSKY repeats ARKHANGELSKY's second argument more emphatically in his 1946 paper. Regrettably subsequent researchers either accepted this argument or just did not care and ARKHANGELSKY's term became popular not only among Russian geologists who may worry about national priority but among western geologists too.

5.2.3. Wave Propagation and the Platform Interior

The issue with the naming of the Russian craton is a prelude to the discussion of a more serious problem, namely, is the Russian platform a deformable object and if yes, by what means? As we have seen above, KARPINSKY (1987, 1894) related deformations of the sedimentary cover of the Russian platform to the orogenic process in the Urals and the Caucasus (Text-Fig. 12). KARPINSKY interpreted deformations of the platformal cover in the southern part of the Russian craton as initiation and decline of an orogeny that he called the "kryazh" formation[11]. SUESS had included the information about these deformations in "The Face of the Earth" however he did not use it much. In the second edition of his 1894 paper KARPINSKY under SUESS' influence was very specific in the explanation of the deformations in the platform (KARPINSKY, 1919b). He disregarded SUESS' hesitations in the interpretation of the Urals and assigned the Urals to the Altaids. In his model, the Urals appear as the peripheral arc of the Altaids. Thus, the propagation of the Altaids to the west was stopped by the Russian platform. Crystalline horsts of the platform determined the shape of the Urals causing their segmentation and arcuate form of the segments. In its turn, Uralian waves propagated into the platformal interior and created a chain of north-south trending welts in the sedimentary cover.

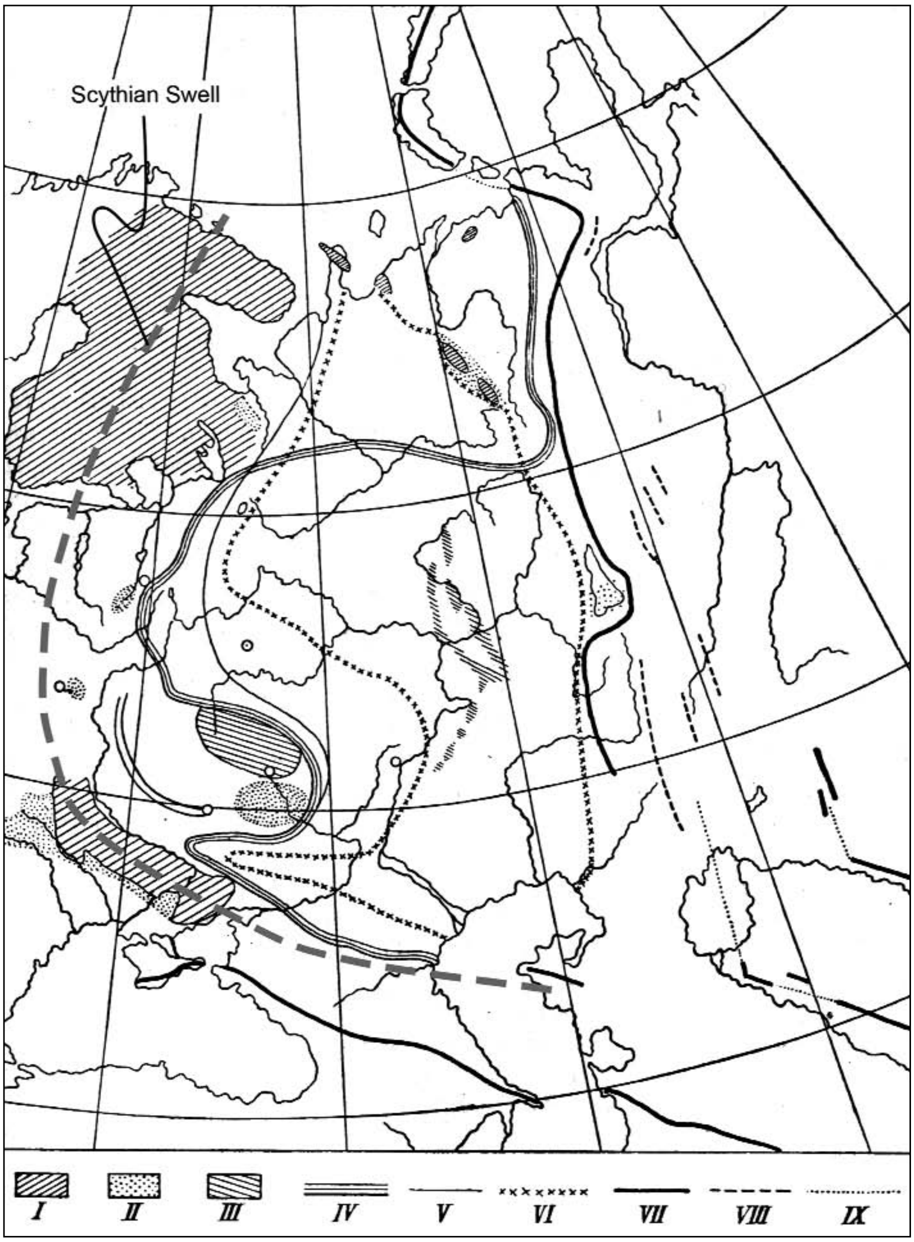
ARKHANGELSKY (1934, 1923) accepted KARPINSKY's ideas on the tectonics of the East-European craton. He combined a series of north–south-trending belts in the eastern part of the platform into a Main Swell and explained it as

> *" ... waves of the Earth's crust that originated under the influence of orogenic motions arriving from the Ural geosyncline."*

In this explanation we see a link to SUESS'S mountain-building waves. TETYAEV (1926, 1912) went farther in the evaluation of the plasticity of the Russian platform and

[11] The Russian words "kryazh" and "gora" have more or less the same meaning that can be translated as "mountain". The word "kryazh" is rarely used nowadays. KARPINSKY uses two of them. Using the word "kryazh" he usually means a region that experienced or is experiencing folding. The world "mountain" he uses when he talks about orographic features. This distinction he did not explain in 1887 and 1894 papers but the different meaning of these terms is very clear in his 1883 paper. KARPINSKY was not very inventive in suggesting new terms. He did not suggest a proper name for the Russian Platform though his description of it is tectonic and concise. His zone of "kryazh" formation became well known when Suess suggested to call it the KARPINSKY Lines.

Text-Fig. 12.
Deformations of the Russian platform in accordance with orogenic movements in the Urals and Caucasus (KARPINSKY, 1919).
Thick gray dash line indicates the Scythian Swell suggested by VON BUBNOFF (1926). KARPINSKY's captions to the figure: I – crystalline horsts, II – submerged parts of the horsts, III – gentle anticlines, IV – the western boundary of the early Carboniferous basin, V – the western boundary of the late Carboniferous basin, VI – the boundary of the Permian basin, VII – the Urals (its western Carboniferous outcrops) and ranges in Crimea, Caucasus, and Central Asia, VIII – Mugodzhar and structural trends in the eastern Urals, IX – inferred connection of fold trends the Urals and Asia.



inferred that Caledonian and Variscan orogenic deformation created a system of wide and gentle folds in the cover of the platform. VON BUBNOFF (1926, 1952) further developed these ideas. He defined the Scythian swell as a wide positive structure, a young trend-line, within the Russian craton. The Scythian swell consists of the Ukranian shield, the Poless anticlise, and the Baltic shield. This swell separates two large depressions – the Moscowian and Byelorussian (Polish-German) syneclises. In the east, the Scythian swell continues to Mangyshlak (Text-Fig. 12). To the west and northeast of the Scythian swell, VON BUBNOFF sees a chain of positive structures that repeats the shape of the swell. In some conformity with the swell are the Urals that form an arc, which is sharply bent south of the Aral Sea in the Sultauizdag region. VON BUBNOFF interprets his swell as an arc, individual parts of which did not have the unity in their previous geologic and tectonic history. All of these parts were united by cyclic, recurrent initiations of the stresses and their propagation. There is a great similarity between VON BUBNOFF's interpretation of swell with the theory of waves suggested by SUESS. In contrast to SUESS VON BUBNOFF's waves operate within the ancient structures such as the Russian Platform and in the European Hercinides where they do not follow the primary tectonic skeleton.

5.2.4. Shatsky Fights the Wave and Defends the Independent Vertical Motion

SHATSKY disagrees with all the interpretations described in the previous section (SHATSKY, 1964b). Concerning the Scythian swell, his arguments are not very strong. For instance, he accuses VON BUBNOFF for uniting heterogeneous structures into the swell, but this is in fact the essence and importance of VON BUBNOFF's concept. SHATSKY cites a discovery of east-west structures in the northern part of the Poless antyclise that contradicts the north-south trend of the Scythian swell. This is not a critical argument because these structures may indicate the initiation of a younger wave that overprints the Scythian swell.

Finally, SHATSKY gives his explanation of the structure, according to which the Poless antyclise is a saddle of the single northeast trending Polish-Moscow syneclise. The syneclise in its turn is bounded in the north and south by the Baltic and Ukrainian shields. These are geometrical descriptions but not explanations of origin.

SHATSKY (1937) contests KARPINSKY (1919a) and ARKHANGELSKY (1934, 1923) who attributed deformations within the Russian craton to orogenic processes in the Uralides. SHATSKY categorically rejects these ideas. He insists that vertical motions that are independent from motions in neighboring orogenic zones controlled all deformations within platformal cover as well as the evolution of syneclises and anticlises. Moreover he showed a favorable attitude to the explanation suggested by MAZAROVICH (1918–1921) who interpreted morphologic features as being inherited from ancient ridges that were buried beneath a thin cover of platformal deposits. I could not find MAZAROVICH's publications that SHATSKY cited but MAZAROVICH had shown a very positive attitude to the ideas of KARPINSKY and ARKHANGELSKY in his later publication (MAZAROVICH, 1938).

There is no need to evaluate these different approaches in terms of the achievements of modern geology. However, the evaluation based on a purely philosophic basis is justifiable. SHATSKY's explanations are simple, thus they are attractive for many people; they are essentially final. Being the end of the scientific inquiry, these explanations do not call for further research. VON BUBNOFF's idea or KARPINSKY/ARKHANGELSKY explanations are complicated. They imply many consequences that must be checked by future studies. In 1926–1937, methods of checking of these ideas were not readily available. They had to be invented. Thus, as VON BUBNOFF's idea provokes intensive future studies, it is more sympathetic to me. SHATSKY's paper shows his negative attitude to the scientific works having similarity to SUESS' tectonic philosophy.

6. Trend-lines in Asia

6.1. Mountain Belts and Mountain Ranges

In the 18th century, mountain ranges were the principle guidelines for understanding of tectonic structure and each mountain range was viewed as some kind of an equivalent of a folded belt in our modern understanding. This concept originated in Europe where close relationships between topography and tectonic structure are characteristic for the Alps and other mountain ranges such as the Pyrenees. VON HUMBOLDT and VON RICHTHOFEN described similar relationships between geological structures and topography in Asia. In many places of the third volume, one may see that Suess often uses trends of ranges for interpretation of the tectonic structure. For instance, SUESS defined boundaries of the East Siberian Tableland (Siberian craton) by arcs of Taymyr and Verkhoyansk ranges. Describing Altay he favorably cites GEBLER who

> *" ... gives an excellent idea of the arc-like plan of the mountains, and this accords with strike of rocks"* (SUESS, 1908, p. 157).

The structure and the evolution of the Altaids were understood from the trends of the mountain ranges. The Ancient Vertex was also defined on the basis of morphological features because on the map it coincides with the High Plateau defined by KROPOTKIN and TSCHERSKI. All other waves in Central Asia were determined from trends of mountain ranges. The solution of the extremely complicated problem of relationships of the Central Asian part of the Altaids with Europe has been found from the analysis of mountain ranges.

Suess PROVIDES the description of Tien Shan arcs by the reproduction of MUSHKETOV's letter (SUESS, 1904, p. 464ff.). From this description, it is clear that much of the norheasterly-trending Tien Shan ranges are at the youngest Triassic in age. The northwest-trending ranges were folded up later than the Tertiary giving the whole a south-concave shape. SUESS interprets Mangyshlak as a continuation of these arcs despite of the fact that Cretaceous rocks are not folded there. From the point of view of modern tectonic studies, this correlation is not justifiable. Fortunately, the peer-reviewing was not too strict in those days and Suess' idea was published. The Mangyshlak structures are the continuation of the southern branches of the Tien Shan orogen but relationships are too complicated to have been sorted out correctly at the end of the 19th century (NATAL'IN & ŞENGÖR, 2005).

SUESS always used orographic features as a primary guide in the detection of trend lines of orogens despite of the careful reading of KARPINSKY (1883) and he was taken to task for doing that by such people as TIETZE (1917). In his 1883 paper, KARPINSKY had described a zone of deformations that, being 300 km wide, strikes in a northwesterly direction from the Mangyslak through Dniepr-Donets to Silesia. These are the famous Karpinsky Lines. The introduction to this short paper is very instructive. KARPINSKY evaluated the role of erosion. If erosion during orogeny is too high, a mountain range cannot be formed. Erosion may eliminate a mountain range; therefore, KARPINSKY points out that a geologist must be careful because some plains are closer to an orogen in their nature than some mountainous areas. In addition to this very important remark, KARPINSKY has shown that the Karpinsky Lines overprint at right angle the Precambrian structures of the Ukrainian shield. In turn, a zone known as Ergeni overprints the Karpinsky Lines. In the second volume, SUESS described these overprinting relationships though he had never discussed the theoretical meaning of them.

Needless to say, SUESS extensively used geological data. Without them, the discovery of the progressive evolution of strictures of the Altaids from the Precambrian in the Ancient Vertex to Cenozoic in Himalaya together with many other discoveries would not have been possible. Concerning Asia we may say that in general, SUESS' methodology of analysis of orography worked well but its resolution could have been better had SUESS paid more attention to the full range of data and conclusions that existed in the Russian literature. Some of them were neglected but some were incorporated in "The Face of the Earth" with modifications that did not endanger the main concept.

6.2. Disjunctive Dislocations

Describing two directions of trends of Precambrian folds to the west and east of Baikal, SUESS warns his readers that the similarity between the courses taken by many of the rivers and trends of folds are apparent (SUESS, 1908, p. 40). Closer examination shows that long fractures and zones of subsidence in fact control the topographic features. SUESS (1908, p. 41) points out that Russians use

> *"... the very expressive term 'disjunctive dislocation' ..."*

for the description of these relationships between old folds and younger structures that control topography. From his narrative, it becomes clear that BOGDANOWITSCH (near the Black Irtysh) and Dmitrii Aleksandrovich KLEMENTS (1848-1914) (in the Valley and Lake Region of Mongolia) have made observations of this sort for the first time and that OBRUCHEV has shown this especially persuasively after his work in Transbaikal region in 1886–1888.

Here we must recall that already in 1892, in his letter to SUESS, OBRUCHEV pointed out that modern topographic features of the surroundings of Lake Baikal were formed from an eroded surface and that Lake Baikal, the most distinct topographic feature of the region, was a graben. Their correspondence is very instructive for the understanding of the evolution of the ideas on the significance of younger deformations in Central Asia. On February 21st, 1895, SUESS wrote to OBRUCHEV:

> *"Each of your letters provides a surprise. Your data on the Ljuk-tshun Graben[12] show that this is a very important element of structure of the whole of Central Asian Highland. I hope that in the nearest future I will receive a map from you on which the location of graben will be shown precisely. I think that this is indeed the main depression or longitudinal graben while majority of other grabens trend at acute angle to strikes"* (Obruchev, 1964b, p. 249).

In his following letter to OBRUCHEV (August 14, 1895) SUESS wrote:

[12] This is known today as the Turfan Basin or Turfan Graben. SUESS shows this graben as Pre-Tien-shan Graben after OBRUCHEV (1901).

"Asiatic grabens, such as Ljuk-tshun, Hanoi[13]*), and others, which are so nicely shown in your maps, are amazing. They are very different from African grabens that have no relationships with folding. Asiatic grabens are closely related to folding, however folding causes contraction of upper levels of the crust therefore down dropping of grabens cannot be imagined without a decrease of stress. The same phenomenon is characteristic for ridges in the western North America. It seems to me that young volcanic rocks have not manifested themselves in your Asiatic grabens, despite their adolescence. Am I wrong"?* (OBRUCHEV, 1964, p. 249).

It seems that in this quotation SUESS was talking about what we now call the concept of orogenic collapse that was re-formulated in 1980s (CONEY & HARMS, 1984; DEWEY, 1988). That is why ŞENGÖR called orogenic collapse „Suess' rule" in 1993. It is well known now that extensional structures of the Basin and Range province are in places oblique to older structure. However let us turn back to disjunctive dislocations in Asia. In the third volume of "The Face of the Earth", there is no explicit explanation of SUESS' understanding of disjunctive dislocations except a short and somewhat confusing section:

"Indeed it would be impossible to explain the formation of a series of sub-parallel fractures and troughs, the course of which corresponds for long distances with the strike of the ancient folds, without assuming a certain amount of tension, acting approximately in the direction of the ancient folds" (SUESS, 1908, p. 41).

Correspondence with OBRUCHEV gives the clearer answer to these concerns. It shows also that Suess had been thinking about the nature of the disjunctive dislocations for a long period of time. The evidence for this as well as the answer for the posed questions is in his third letter that is dated by April 2nd, 1896:

"The fact that longitudinal grabens are common structures in these old folded mountains[14]*) attracted my special attention in your last letter. These grabens are parallel with the strikes of folds and this is very important. In our young folded mountains, e.g. the Alps, the Apennines, etc. we see tight folds indicating horizontal compression. Whenever faults appear they are branching or gentle [=pologii]*[15]*) and also transverse to the folds but they are never parallel with the folds. The longitudinal graben, that is the down dropped block, shows that stress causing the folding is ended and that a reduced stress, though transient in nature, has replaced contraction and made possible the formation of the graben'* (OBRUCHEV, 1964, p. 251–259).

Thus SUESS sees the origin of the disjunctive dislocations in Asia in close relationships to folding and views them as an accompaniment to folding. This view is in unison with the essence of his concept on the development of the structure of Asia – the propagation of waves from the common center to the periphery.

Unfortunately we do not know exactly the reason that provoked and sustained this long discussion. We do not know what OBRUCHEV wrote to SUESS in answer during this discussion because his letters are not published. It is clear however that OBRUCHEV triggered this discussion after the investigation of the Ljuk-tshun (Turfan) graben and sending Suess his unpublished data (SUESS, 1908, p. 167, Fig. 9). These data were published later in 1901 as a diary of the expedition to Central Asia (OBRUCHEV, 1901); however, preliminary reports containing similar sets of data and conclusions were published in 1894 (OBRUCHEV, 1894c). These publications are cited by SUESS extensively in the third volume.

What did OBRUCHEV know? In the Nan Shan and regions around it, OBRUCHEV established Jurassic rocks, which he assigned to the Post-Carboniferous, and the Gobi Suite[16]) of Tertiary age. He also established that the Jurassic rocks unconformably overlie the Carboniferous coal-bearing rocks. OBRUCHEV traced all of these stratigraphic units to the north of Nan Shan and in the vicinity of the Ljuk-tshun Graben. Relationships between the Jurassic rocks and the Gobi suite OBRUCHEV (1901, p. 615–616) describes as following:

" … Jurassic rocks were weakly deformed before the deposition of the Gobi suite. Besides, gradual decreasing of dip angles in the Gobi suite from lower horizons to upper ones indicates that a weak, steady-state deformation occurred continuously during the deposition of these rocks. This deformation caused folding but the disjunctive deformation had happened after the deposition of upper Gobi beds creating normal faults, in places simple in others places forming steps. These faults cut a gentle anticline displacing it southern limb below the surface of the Ljuk-tshun basin and thus form this remarkable basin."

The preliminary report (OBRUCHEV, 1894c) gives additional information on timing of disjunctive dislocations. OBRUCHEV describes trends of folds in stratigraphic units of various ages as well as trends of fractures and faults that have different strikes from the earlier folds. The latter have consistent northwestern strikes and control orographic features which have asymmetric profiles: steep southern slopes and gentle northern slopes. OBRUCHEV interprets these faults as normal faults and infers that all these normal faults were formed during the time interval between the deposition of the Carboniferous series (including the group C) and ingression of Khan-Khai Sea. A north–northwest-striking normal fault perhaps controls a wide transcurrent Chagryn-Gol valley as well as a wide and deep depression of the Ushiling Pass in Momoshan. Finally, N–S- and NNW-striking normal faults control a wide interruption of the Humboldt Range" (the 1894 report is cited from OBRUCHEV, 1958, p. 419).

The Gobi suite was deposited during the ingression of the Khan-Khai Sea. Thus, the normal faulting had a protracted history from the post-Carboniferous in Nan Shan to the recent in the Ljuk-tshun Graben. The formation of normal faults was interrupted by contraction that caused folding of the Jurassic rocks and the Gobi suite.

Two very different tectonic meanings of the disjunctive dislocations are clearly seen from above. Suess implies close relationships between primary folds that created the Altay arcs and the formation of grabens. It means that for determination of trend lines one can use both fold trends and strikes of disjunctive dislocations. Grabens follow folds; they are formed when stresses causing folding fade away, thus grabens in fact mark the fold axes. SUESS (1908, p. 40) said about this explicitly in the third volume:

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13) In the original text, the citation of grabens is given as "the Ljuk-tshun, Hanoi and other [grabens]". This is obviously a mistake made by the translator. The Ljuk-tshun or Turfan graben has no relationships with structures in Vietnam. Besides, it is hardly possible that OBRUCHEV discussed with SUESS the structure of Southeastern Asia. In fact the names referred to are Ljuk-tshun and Hami, the only two cities in the graben that SUESS ended up calling Pri-Tian-shan'scher Graben (SUESS, 1908, plate VII). As the translator must have had manuscripts of letters before him, this error is understandable.

14) OBRUCHEV and SUESS discuss the Sayan Mountains.

15) I understand this gentility to be slight obliqueness to the trend of the fold axes. Unfortunately as I was writing this paper I did not have access to SUESS' original letters, so I am dependent on the Russian translator. I fear that the translation is not of the best quality.

16) The Russian term suite refers to a local stratigraphic unit that is defined on the basis of lithological facial features and has its own paleontological content (ZHAMOIDA, 1992).

“These long fractures sometimes coincide for a considerable distance with the strike of the folds; in other places they intersect the strike; but on the whole, as we have observed above, they give rise to a configuration which recalls the course of the ancient folds.”

Precisely for this reason disjunctive dislocations are plotted on the Tectonic map of the Altaids (SUESS, 1908).

On the contrary, Russian geologists put more emphasis on disagreement between strikes of the disjunctive dislocations and strikes of ancient folds. BOGDANOWITSCH (1892) viewed the Trabgatai Range as a horst bounded by faults that obliquely cut strikes of folds. TSCHERSKI (1893) noted similar relationships in the Tas-Kystabyt range in the Verkhoyansk region. KARPINSKY (1894) also made a clear distinction between folded (plicate) zones and disjunctive zones (subsidence controlled by faulting) setting them against stable areas (platforms). Thus, tectonic regimes that created these three tectonic settings had been viewed as irrelevant to each other.

During the Central Asia expedition in 1893–1894, OBRUCHEV showed a very complicated evolution of structures of mountain ranges. Beside Nan Shan and the region of the Ljuk-tshun Graben he observed relationships between orographic features and trends of folds in Qaidam and Quinlin that are similar to those in the Nan Shan and in the Ljuk-tshun Graben, i.e. folds and faults do not everywhere parallel one another.

Later OBRUCHEV (1915) described the same relationships in the Altay and the Junggar regions where he found out that Paleozoic folds were completely eroded in the Paleozoic and modern topography was controlled by later faulting. According to OBRUCHEV Paleozoic rocks always reveal a complicated pattern with frequent changes in strike. First in the Mesozoic and then in the Tertiary, these folds were cut by steep faults that fan from the east to the west. OBRUCHEV inferred that these faults were formed because of vertical motions. Many Russian geologists shared OBRUCHEV’s interpretation for almost 80 years. Only in 1996, ŞENGÖR & NATAL’IN (1996) showed that these faults are strike-slip faults.

7. What Suess Missed in Russian Studies

7.1. Usage of Rock Composition for Correlation of Mountain Ranges

It is widely accepted that SUESS was the first who had shown that the correlation of mountain belts must include stratigraphic and structural data. However, dealing with Asia, SUESS mainly relied on trends of mountains. When it is possible, he gives information on strikes of rocks; if strikes of rocks and trends of mountains disagree with each other, he describes strikes of rocks at length.

At the same time, SUESS did not pay much attention to composition of rocks giving this information as a background in the description and rarely using it for correlation. For instance, SUESS made a distinction between the Russian Altay and Gobi-Altay. The first range consists mainly of schists, while gneisses and Archean rocks are wide spread in the Gobi-Altay (SUESS, 1908, p. 159). The second example comes from Nan Shan where the Pustynnaya dolina[17] of Obruchev (1901) separates predominantly Archean gneissic rocks in the south from mainly Paleozoic rocks in the north. Now this zone is incorrectly interpreted as the Danghe Nan Shan suture (e.g. YIN & HARRISON, 2000)[18].

There are two aspects in the correlation of mountain ranges based on the composition. One is a regional correlation and another is a global correlation. The global correlation was not very important in SUESS’ times because at the end of the 18th and in the first half of the 19th century the origin of mountain belts due to the uplift of primary rocks as well as their symmetric structure was a common view formulated by HUTTON, MICHELL, PALLAS and VON BUCH (ŞENGÖR, 1990).

In Russian works one may see a different approach. TCHIHATCHEFF (1845) noted that the abundance of recent lavas does not allow the correlation of Altay with mountain ranges of Hungary, European Turkey, Java, and eastern Siberia (Far East of Russia). Instead, he compares Altay with Sierra Nevada in Spain taking as an additional criterion a wide distribution of slates. A year later SCHUROVSKII (1846) also used the composition and structure of the range for correlation of the Urals and Kuznetskii Alatau. Both ranges are of the north-south trend. Besides the similarity in orientation, which have been noted by HUMBOLDT and HELMERSEN (1838), the crystalline rocks of these two ranges are exposed not only along the central axis as they do in many other ranges but constitute also eastern slopes down to the foothills. Volcanic rocks dominate over other crystalline rocks in the Kuznetskii Alatau. Concerning sedimentary and metamorphic rocks SCHUROVSKII reports that the Urals is rich in shales, talk, chlorite, and amphibole schists, and serpentinites while in Alatau, limestone is the main rock type with subordinate shales with transitions to siliceous shales. SCHUROVSKII noted also the difference in the composition of intrusive rocks and asymmetry in the distribution of main lithologies in both regions. Finally, he correlated all these features with the metallogeny of these two ranges.

The regional correlation was more important for the model of the Altaids especially when disagreement between orographic features and strikes of ancient folds had been noted. Describing Kuznetskii Alatau and Altay, SUESS lists the same rocks among which schists take the first place. TCHIHATCHEFF (1845) and SCHUROVSKII (1846) noted that in Kuznetskii Alatau limestones are wider spread than schists. They describe also that the composition of volcanic rocks is different in Altay and Kuznetskii Alatau. Today some geologists interpret these limestones as remnants of Vendian seamounts (DOBRETSOV et al., 2004). In general, amount of subduction related magmatic rocks is greater in Alatau than in Altay where subduction-accretion complexes dominate other rocks types of subduction plate boundaries.

It is worth to note that sometimes search for the similarity of trends of mountain ranges forced SUESS to neglect structural data, which he accurately reproduced in the description. For instance, SUESS sees a similarity of trends of mountain ranges of Kolyvan with the Kirghiz folds that are distributed in the northern Kazakhstan (SUESS, 1908, p.163). The main reason for similarity is the strike and continuity of trend lines. However, in the Kolyvan Range, Devonian and Carboniferous rocks are folded while in the Kirghiz folds

[17] SUESS correctly translated this name as the Desert Valley.

[18] ŞENGÖR & NATAL’IN (1996) interpret Nan Shan as a Paleozoic subduction-accretionary complex repeated along northwest-striking strike-slip faults. YIN & HARRISON (2000) criticize this interpretation pointing out that “the strike-slip faults required by the model of ŞENGÖR & NATAL’IN (1996) have not been described in any report of Qilian geology”. This is not true and their remark results from their inadequate command of the literature. OBRUCHEV (1894, 1901) has described numerous changes of strike of steep dipping foliation that he called “knee-like bends of strike”. He indicated also that these bends have asymmetric shape. The origin of this structure can have only one explanation, namely, shearing parallel with the strike of an orogen. A map of one of these bends indicates the left-lateral shearing that is in accord with ŞENGÖR & NATAL’IN’S model. That is one piece of evidence of strike-slip faults that ŞENGÖR & NATAL’IN have envisaged. There are numerous others both in the older and the more recent literature as ŞENGÖR et al. (1993) also pointed out.

" ... the Devonian sandstone is almost horizontal; the Carboniferous limestone with Productus giganteus lies in a very shallow basin" ... (SUESS, 1908, p. 162).

I want to note here that in those days the usage of composition in correlation of mountain belts standing far apart was not popular and had not been developed. Talking about SUESS and Russian geologists, SUESS and Asia, and about tectonics in general it is worth to note that SUESS notes that TSCHIHATSCHEV (1845) has compared the Altay Mountains with the Sierra Nevada of Spain because these

" ... broad monotonous ridges [are] wholly composed of schists ... " (SUESS, 1908, P. 157).

That is the beginning of our main method in modern tectonics.

7.2. Meaning of the Disagreement Between Orographic and Geological Features

According to D. MUSHKETOV (1935) the most significant contribution of SUESS to the understanding of Eurasian folded zone is the acceptance of the preservation of a single direction of folding during the considerable time interval starting with the Precambrian though Russian geologists noted the disagreement of folds and ranges already in the first half of the 18th century. (e.g. HELMERSEN, 1838).

MUSSHKETOV (1886) described a complicated history of formation of mountain ranges in Tien Shan. The distribution of Paleozoic granites and related structures follow a northeasterly trend. The orographic features are characterized by a northwesterly trend. MUSHKETOV established almost all Paleozoic systems in the Tien Shan except the Cambrian and Permian therefore he knew exactly what rock assemblages were formed in the Paleozoic. MUSHKETOV found that Mesozoic rocks unconformably overlie the Paleozoic ones but they reveal concordant relationships with Tertiary deposits. Thus, it became clear for him that mountain building processes started in the Tertiary. VAINER (1956) gives a good overview of this point. MUSHKETOV persuaded geologists to look carefully at geological history of studied regions, which, as Tien Shan case had shown, could be very complicated. In fact, he distinguished two trends in Tien Shan: the Paleozoic NE trends and Tertiary NW trends. He tried to unite the Paleozoic trend with trends in Kuen-Lun. Although it is not explicitly said in the text, uniting these trends one can get an arc that is of north-south direction and strongly convex to the west. MUSHKETOV's Tien Shan arcs that SUESS used in his synthesis are young arcs superimposed on older ones. MUSHKETOV was wrong with the geometry of the Paleozoic arcs, but his message was clear. SUESS missed this message.

Data that OBRUCHEV sent to SUESS from Nan Shan were of the same sort. During the first expedition to Central Asia in 1892–1894, OBRUCHEV established a long geological history that preceded the formation of grabens. The Jurassic history of the Ljuk-tshun Graben was not very clear for OBRUCHEV. On the contrary, the structural evolution of Nan-Shan was well understood and in fact now it looks as very modern (OBRUCHEV, 1894a). Stratigraphic succession was divided into:

1) Granite-gneiss and granite unit.
2) Archean (?) gneiss and schists unit, consisting of amphibole- and micaschist, gneiss, marble.
3) Dark green schist unit.
4) Silurian limestones, phyllite, and slates with well developed cleavage.
4) Devonian (?) red shale and sandstone.
5) Carboniferous shale and sandstone;
6) Unconformably lying post-Carboniferous variegated shale and clastic rocks that in places contain coal seams.
7) Reddish unconsolidated coal bearing deposits of Khan Khai sea or Gobi series.

OBRUCHEV reported that structural styles and orientations of structures were different in different stratigraphic units. The granite-gneiss and granite unit strikes to the east-northeast, and Nan Shan northwestern trends are similar to structural trends of the second and younger unit. Folds in different unit reveal various morphologies and become simpler up the section. The post-Carboniferous rocks usually form simple folds often showing N–S and NE trend but in places they are tightly folded and strike in accord with Nan Shan trends. The Gobi series is mildly folded and then faulted. Normal faults are characterized by subsidence of the northern walls. In the southeastern part of Nan Shan OBRUCHEV (1894b) noted an unusual structure of the Silurian unit:

"I do not describe secondary deformations that are especially common in the Silurian limestones and shales that can be explained by modification of the earlier folds by a force of a new direction."

We see here that OBRUCHEV has managed to recognize not only progressive deformation but also superimposed deformations and changing of folding direction with time.

In 1895–1898, OBRUCHEV worked in the Transbaikal region where he had established numerous disjunctive dislocations that control modern topography. He found there that disjunctive dislocations controlled the distribution of Tertiary(?) coal-bearing rocks and volcanic eruptions. It seems that in the first reports OBRUCHEV (1899) somehow neglected Jurassic rocks that had already been established there (BRAUER et al., 1889; GERASIMOV, 1896) inferring that disjunctive dislocations were Tertiary or even Quaternary in age.

SUESS separated the Archean history of the Earth (which for him meant the whole of the Palaeozoic) from subsequent evolution during which contraction of the Earth affected isolated regions. However SUESS did not pay much attention to differences of trends of rocks of various ages that OBRUCHEV reported in Nan Shan.

7.3. First Observation of Mélange

In the lower reaches of the Chuya River TSCHIKHACHEV (1845) described abnormal relationships of large bodies of massive Devonian limestones that were surrounded by Silurian shales. Bedding in limestones is discordant to surrounding shales. TSCHIKHACHEV suggested that the shales penetrated overlying limestones because of tectonic forces and later metamorphism solidified contacts between rocks of different ages. In other places, TSCHIKHACHEV described the appearance of jasper as fragments (blocks) in shales. Is it the first observation of a mélange that is widely spread in this region as we know now? SUESS, who himself had recognised mélanges in the northern Carpathians (SUESS, 1858; see ŞENGÖR, 2003), did not seem to have recognised the significance of TCHIHATCHEFF's description of rocks very similar to those of the Klippen Belts of the northern Carpathians and that we now know to be mélanges. This is surprising.

8. How Well Did SUESS Himself Understand the Problem of the Ancient Vertex?

In the introduction to the third volume Suess makes a clear distinction between a tableland and a mountain chain

" ... the contrast between which forms the basis of many an excellent description of a country" (SUESS, 1908, p. 3).

Suess continues saying that

"... beneath these tablelands are to be found, always and everywhere, folded rocks. The folding may only occur at a great depth, but that it is nowhere absent appears from the fact that all the Archean rocks of the earth have suffered folding or an equivalent compression ... "

Moreover, further on (p. 4) one may read:

"... that the folding force was once active over the whole globe, but it is restricted at present to particular regions ... "

The distinction between tablelands and chains and the distinction between folding that affected the whole of the globe and folding operating in a particular region is very important in the interpretation of SUESS' understanding of the Ancient Vertex. Is it a nucleus overgrown by younger structures or is it a starting point of the growth? Unfortunately, the answer to this question is not very clear in SUESS' narrative. I will try to show that the second choice in the posed question fits the logic of "The Face of the Earth" better.

In the Russian literature, the concept of the Ancient Vertex is always related to SUESS despite the fact that OBRUCHEV greatly modified it. As it has been mentioned above, OBRUCHEV considered the work on this concept as one among five principal scientific problems that occupied him during his lifetime. Developing the concept, OBRUCHEV presented the Ancient Vertex as the oldest part of Asia to which younger structures were added in the Proterozoic and Paleozoic. He largely extended the size of the vertex (OBRUCHEV, 1927) including in it the Chinese Altay, Kuznetskii Alatau, and some ranges in Altay. The Anabar shield and Taymyr arc were also assigned to the Vertex being separated from it by the Archean diastrophism and the development of the intervening geosyncline. A similar geosyncline evolved between the Ancient Vertex and Anabar. Their closure in the Eozoan (Proterozoic) made the basement of the Siberian platform. In accord with this view, the platform appears as a younger addition to the Vertex.

The same understanding of the concept has been assigned to SUESS. One may see this understanding of SUESS in SHATSKY (1932), D. MUSHKETOV (1935) but the most explicit presentation of this view we may find in (MAZAROVICH, 1938, p. 425):

"In his remarkable work 'The Face of the Earth' (Das Antlitz der Erde), Eduard Suess considering the structure of Asia, has defined the Precambrian of Sayan, Khamar-Daban, Khantei and other surrounding areas including Nerchinck Dauria as the "Ancient Vertex of Asia" (Der alte Scheitel Asiens). He considered this region as the most ancient part of the continent, its core, around which younger waves had been growing thus forming "Asiatic edifices". The whole of the region that is located between Yenisey and Lena has been viewed as younger structures added to the "ancient vertex"

If this understanding is presented to geologists who have never read SUESS and who worked in Siberia discovering new structural relationships and fossils in rocks that were previously allegedly assigned to the Archean and Proterozoic, the fate of the concept would be at great danger.

We must recall also, that the pernicious geosynclinal concept became very popular after SUESS' death. In 1934, ARKHANGELSKY and SHATSKY, the leaders of the main academic geologic institute in USSR, published the first tectonic map of the USSR, and thus suggested the main principle of tectonic cartography, namely delineating zones of similar age of folding. This concept was gladly accepted not only in Russia but also in Europe after its adoption by the International Geological Congress as the main method for the compilation of the Tectonic map of Europe. Under these circumstances, the search for unconformities became the main target in tectonic studies of orogenic belts. However, the Altaids are very different from orogens that are produced by collisions. In the Altaids, subduction-accretion complexes constitute the main volume of the orogenic collage (ŞENGÖR & NATAL'IN, 1996). As it is well known from modern examples, a slope apron and forearc basins steadily overlie a growing accretionary wedge; migrating magmatic arcs invade it. Therefore, the Altaids present an inexhaustible source for new discoveries of unconformities and orogenic magmatic rocks each of which would mark a closure of a geosyncline. I do not want to say, however, that these studies were useless. The steady growth of the Altaids could not be understood properly without them.

The geosyncline concept implies that cratonic areas are the oldest in the earth. Placing the Vertex at the side of the Siberian craton and the interpretation of the Vertex as the oldest structure, to which the craton was added, indeed looks as a great mistake. Discovering of non-Archean episodes of folding in the Vertex only aggravated this mistake. Unfortunately, I must conclude that OBRUCHEV's development of the concept of the Ancient Vertex has played a negative role.

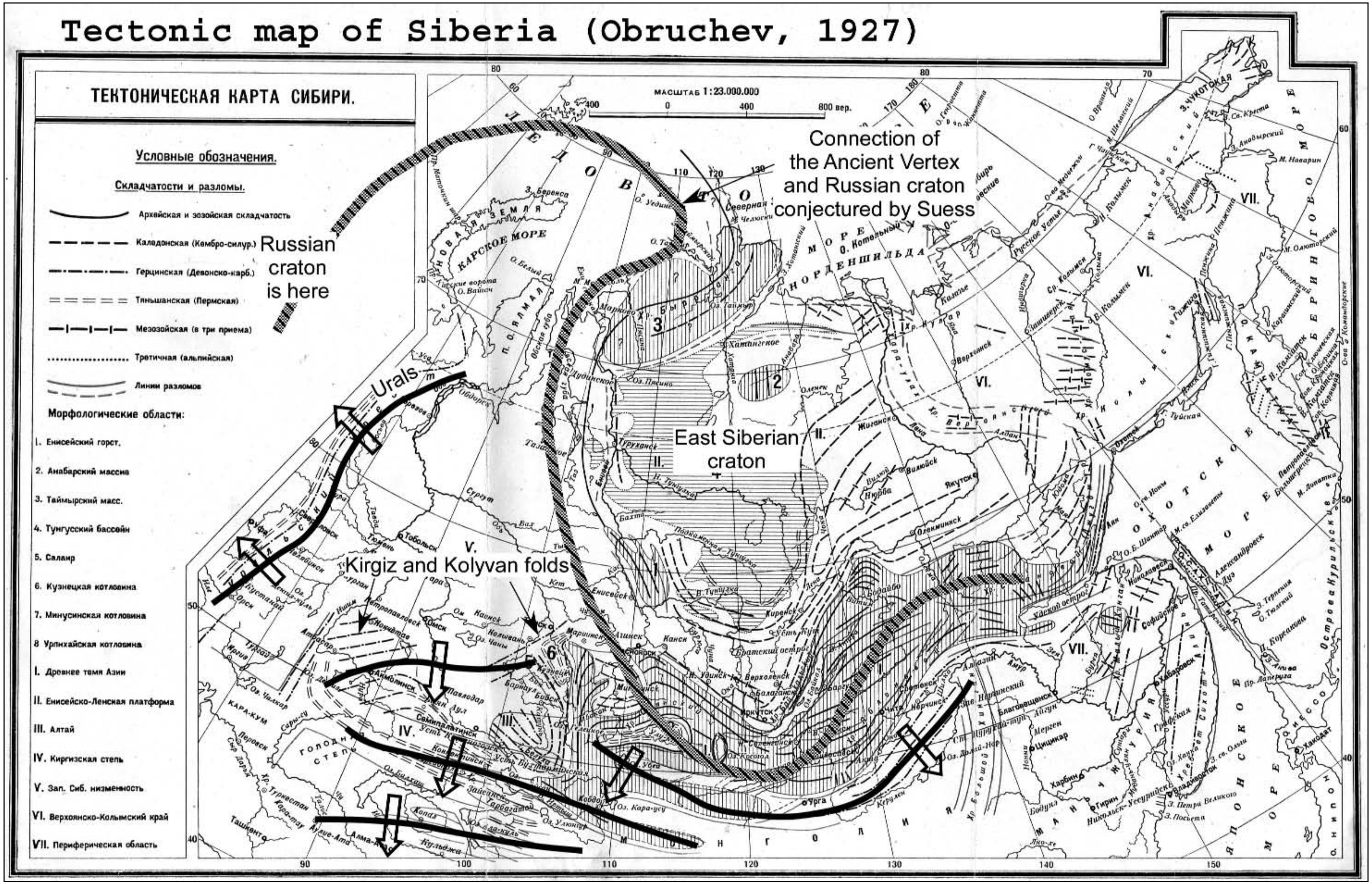
8.1. Tableland and Platform

SUESS also made a few deviations from the central line of his concept that caused confusion. First is the different naming of two largest cratonic areas in Eurasia. The Russian craton was called the platform but not a tableland similar with the cratonic area in Siberia. It is difficult to apprehend this different naming because according to SUESS the structure of Russian and East Siberian cratons is identical: both have the Precambrian basement and platformal cover consisting of Cambrian and younger deposits.

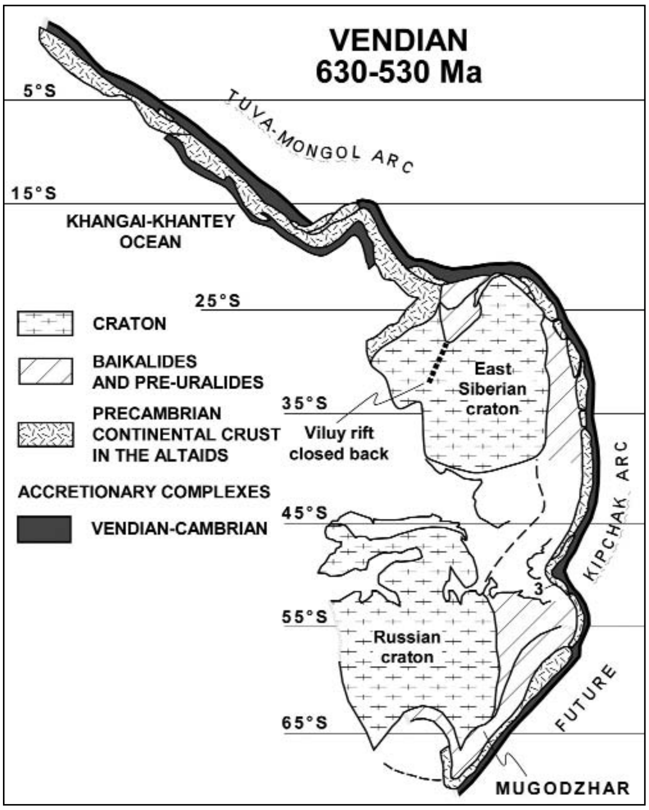
Secondly, after discussing the orientation of trend lines in Western Siberia and Kazakhstan SUESS made the suggestion that the Russian platform may represent the continuation of the Ancient Vertex. Actually, he had some structural reason for this suggestion. East–west trends of folds in the Kolyvan range are in odds with northwestern strikes of Altai and eastern Kazakhstan. In the west, they plunge beneath the cover of the West Siberian basin. Actually, it was reasonable to see the Kolyvan continuation in the Kirghiz folds that were described as east-west or east-northeast striking. This suggestion was in accord with the available data in those days. If the Altaids are bounded in the north by east-west arc, the vertex could follow this trend being to the north of the Kolyvan folds.

The only problem of this interpretation was the Urals. Taking into account Russian studies SUESS described the Ural structure as the west-vergent. If the Russian platform is a western continuation of the Ancient Vertex this vergence is "wrong" (Text-Fig. 13). SUESS analyses the strikes in the Precambrian rocks that constitute the basement of the Russian platform and finds that these strikes are parallel to the strike of the Urals. From this parallelism, SUESS infers that the Urals is a posthumous structure. Regardless of how SUESS has come to this conclusion, we must agree with SUESS that the Urals is not the Altaids (SENGÖR & NATAL'IN, 1996). The Altaids evolved facing a pre-Altaid ocean while the Urals (as they were known to SUESS) is a product of a simple Wilson cycle – the opening of the Ural ocean in the Ordovician and its closure in the early Carboniferous. His intuition did not betray the master.

Modern studies partly confirm the continuation of the Vertex to the Russian craton but not across the Ob region as SUESS might infer. The pre-Uralide structures in the Pechora region are the continuation of the Baikalides distributed along the western margin of the Siberian craton. However, this continuity can only be seen in palinspastic reconstructions made in accord to paleomagnetic data (ŞENGÖR et al. 1993; SENGÖR & NATAL'IN, 1996) (Text-Fig. 14).



Text-Fig. 13.
"Wrong" vergence of the Urals.
I used OBRUCHEV'S tectonic map of Siberia as a background. Vertical ruling indicates the extend of the Ancient Vertex in OBRUCHEV'S interpretation. Connection of the Ancient Vertex and the Russian craton suggested by SUESS is shown by thick line with a pattern. Note THAT Suess did not specify the position of this connection. According to his opinion it could be somewhere to the north of the Kirgiz-Kolyvan folds. Black lines indicate structural trends of the Altaids and the Urals. Block arrows show the vergence. Note that vergence if the Ural in respect of the Ancient Vertex/Russian craton is different than vergence in the Altaids.



Text-Fig. 14.
The continuity of the Baikalides and Pre-Uralides on the Vendian paleotectonic reconstruction (ŞENGÖR AND NATAL'IN, 1996).

8.2. How Would I have interpereted the 'Ancient Vertex' if I Were Suess

The concept of the Ancient vertex has caused much discussion in the geological literature for over half a century and even today it is unclear to many what SUESS really meant by it. Below I present my thoughts concerning it, putting myself in SUESS' shoes. This is not doing history, but thinking aloud about what seems was within the important concept formulated at the transition between 19th and 20th century.

As we have seen from quotation at the beginning of this section SUESS has made a distinction between the uniform distribution of the Archean folds and discrete distribution of younger deformations. SUESS was a follower of the contraction theory of folding therefore this distinction implied that the rate of contraction changed with time. During the Archean, there was uniform contraction (Text-Fig. 15). Directions of forces were difficult to know about and they were not discussed in the third volume. The clear pattern appeared later when contraction-related deformation started to operate in isolated regions. Thus, the Ancient Vertex should be the oldest part of Asia but younger the Archean time of the pervasive folding. The Ancient Vertex is (or should be according to what I understand to be Suess' train of thinking) the first fold or wave of the oldest discrete deformation (Text-Fig. 15). Its clear structural pattern was noted and described by TSCHERSKI and incorporated into SUESS' concept of the tectonic evolution of Asia.

Why emphasis shifted from the first fold to the oldest part? First, a linguistic problem may be involved.

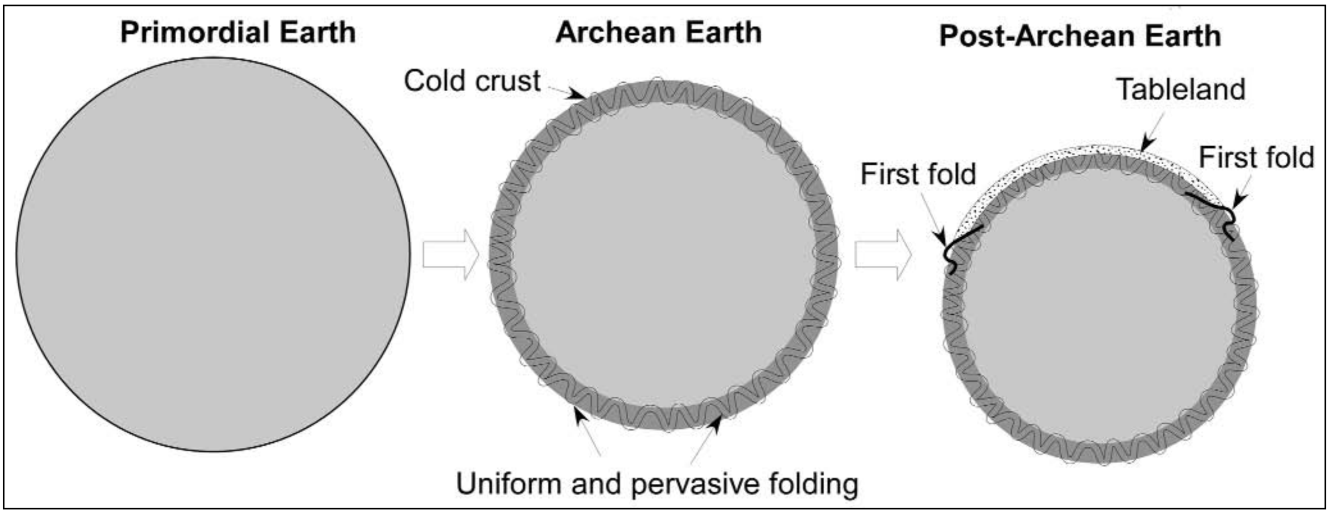
> *"This extensive region we are about to discuss forms, by virtue of its position and structure, the most ancient vertex of the Eurasian folds ... "* (SUESS, 1908, p. 39)

The main meaning of the word "vertex" in Russian is the highest part of a human head. Allegorically it is used for designation of the top of a large mountain. There are some other meanings but none of them has a relevance to a fold. At the same time, the meaning has also no relation to a nucleus or to nucleation. Basic dictionaries show that German "der Scheitel" has the very same meanings. Thus, SUESS' choice of the term was not the best. However, I think SUESS meant the first fold or wave. It is very clear from the text where the Altay arcs are called the younger vertex. The Sayan orocline (SENGÖR & NATAL'IN, 1996) was also called the vertex.

Secondly, at the very beginning of the description of the Vertex SUESS (1908, p. 39) clearly stated that

> *"... the rocks and the folds of the vertex are extremely old."*

Here we see some disagreement with quotations that are presented at the beginning of this section. Are they faceless Archean folds or they are the Eurasian folds that have unique pattern and place? Describing these folds SUESS always emphasizes their regular pattern that follows the Baikal and Sayan trends. The emphasis of their extreme age ("Archaean") led to confusion.



Text-Fig. 15.
The possible meaning of the Ancient Vertex within SUESS' train of thinking.
Cooling of the primordial Earth created Archean folds everywhere. These folds as well as their trends are complicated. Later, folding occurred in particular regions and the trends of these folds acquire a specific pattern as described by TSCHERSKI, SUESS, and OBRUCHEV in the Ancient Vertex. Thus the Vertex is the first fold or the starting point of the Altaid waves.

In fact, data on multiple folding were available to Suess. For instance, TSCHERSKI (1886) has established two stratigraphic units within the Archean rocks of the Baikal region. The older unit consists of gneiss, granite-gneiss, and granite. Marbles predominate in the upper unit. TSCHERSKI suggested different origin of these units. He noted that northeastern and northwestern strikes and intricate folding were characteristic for the lower unit but he characterized the general structure as the Archean as a system of northeast-striking folds. Within the basement of the Yenisey Horst, JATSCHEWSKI (1894) distinguished the Archean and pre-Silurian stratigraphic units separated by an unconformity. He did not describe the structure of the lower unit but indicated northwest-striking folds in the upper unit. SUESS used these data for the description of the structure of the Ancient Vertex and did not mention the unconformity at the base of the upper unit where these folds were.

These two examples can be supplemented with similar examples from Olekma-Vitim region and Transbaikalia. SUESS cited all these publications. They were of great importance for the understanding of the vertex concept and making distinction between the Archean and Eurasian folds. The disregard of these data may be interpreted as if SUESS did not understand himself the concept of the Vertex well enough.

Unfortunately, OBRUCHEV did not help him in the clarification of the concept of the Ancient Vertex in the first half of the 20th century. In his first book dealing with the geological description of Siberia he writes:

> *"My studies in the south-western Transbaikalia have forced me to conclude that it is necessary to make a distinction between deformations of the lower system (Azoan) and the upper one (Archeozoan). In the first one I could not establish any predominant direction of foliation not only in the whole of the country but also within individual ranges: everywhere variations are too great. … In the Archeozoan, it became possible to outline the Sayan direction in the west and the Baikal direction in the east starting with lower reaches of the Selenga River or, in other words, to establish the existence of a large arc-type fold concave to the north."* (OBRUCHEV, 1927. p. 19).

We see here the very clear representation of SUESS' idea on the development of deformation on the Earth; the difference between the earliest disordered deformations and the first appearance of the later ordered deformation. If I were SUESS I would have taken this concept as the basis of the Vertex concept as the data were available to him via TCHERSKI and JATCHEWSKI. SUESS did not do that and stuck to the general Archaean age of the Vertex. Unfortunately OBRUCHEV obstinately followed him to the bitter end. In the final chapter of his book on Siberia (OBRUCHEV, 1927, p. 318) dealing with the definition of the tectonic he units states:

> *"The Ancient Vertex is undoubtedly a continental block, the 1st order block. That was created already in Archean times by the first orogenic movements that were accompanied by intrusions of large plutons. Strongly foliated, injected by intrusions, and recrystallized old sediments form a block incompliant for later folding."*

In the section dealing with folding and fold systems one can read

> *"In Siberia, the oldest system of folds is Archean in age in the Ancient Vertex. They form two arcs concave to the north[19]. … This primary folding characterizes the Ancient Vertex and together with faults represents principle trend lines".* (OBRUCHEV, 1927, p. 326).

[19] OBRUCHEV means here one fold in Kuznetsk Alata and another one in the Patom Highland.

As we see the clarity of the concept of the Ancient Vertex suggested by SUESS became muddled. We can see also that OBRUCHEV's own concept is inconsistent with his own description of the data.

9. Conclusions

One of the greatest concept in the history of tectonics was born because of genuine attempt to learn regardless of state or language barriers. Truly gentlemanly behavior of the key players of the story is very instructive and admirable. The work of SUESS and his Russian friends deserve additional and more thorough studies. What I could do here is just to scratch the surface and to indicate some problematic areas that caused me much reflection.

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