The Contribution of Austrian Geo-Scientists to the Geological Exploration of Pakistan

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1. Introduction

In the frame of Aloys Sprenger Symposium in Islamabad, October 26-30, 1996 - organized by the Austrian Embassy - the author had the honour to give a lecture on the highlights of „The Contribution of Austrian Geo-Scientists to the Geological Research in Pakistan". The lecture was illustrated by numerous slides and overheads documenting the most important papers with fossil-plates, geological maps and sections etc. in Palaeontologica Indica, in the Records of the Geological Survey of India and published in European journals. Another goal of the lecture presented was to work out the relations of the British Geological Survey and its outspring in Calcutta, the Geological Survey of India (established in 1851), with the Austrian geoscientific community, i.e. the Geological Survey of Austria (established in 1849) and the Universities of Vienna and Prague. The role of a few famous Austrian „key-persons" in geosciences with excellent international connections was

enlightened (e.g. Wilhelm von Haidinger, Eduard Suess, Franz von Hauer). They were not only famous scientists, organizers and scholars, but lived for the idea of humanistic cosmopolitism, an idea so rare to find in present days Austrian geoscientific management.

The goal of the present paper is to point to a few most important Austrian geoscientists, who stimulated the knowledge on the geology of the Subcontinent, with particular emphasis on the territory of Pakistan. While the first scattered geological annotations were published in monographies by missionaries on various topics (Tieffenthaler 1785-1789) and travellers interested in natural sciences (v. Hügel 1840-1848, Honigberger 1851), systematic geoscientific work by Austrians in Pakistan commenced with a comet, namely Ferdinand Stoliczka in 1862. The classical period of Himalayan research is strongly connected also with other famous geoscientists of the Austrian-Hungarian monarchy e.g. Waagen, Feistmantel, Griesbach and Diener. After the breakdown of the Austrian-Hungarian monarchy in 1918, Austria shrimped to a small country and the striking influence by Bohemian geoscientific institutions and of proverbial creative Bohemian/Moravian scientists - as Stoliczka and Feistmantel - belonged to history.

In the period between the two World Wars geological activities of Austrians in connection with Pakistan are almost entirely restricted to work in scientific institutions and laboratories on material collected during the classical period of geological research. Since World War II, however, various Austrians were active in Pakistan, most of them in joint ventures. The activities comprise geological research during mountaineering expeditions (e.g. Gattinger, Diemberger), cooperation in mineral raw materials exploration (AUSTROMINERAL Co. Ltd., OMV-Pakistan Co. Ltd.), basic and applied field research and geological mapping (Fuchs, Gattinger, Gamerith, Buchroithner). Also the palaeontological and petrological basic research in Austrian scientific institutions continued (e.g. Flügel, Mostler, Vogeltanz). Last but not least, it should not be forgotten, that the steady increase in knowledge especially on the area of the Westen Himalayas, the Hindukush, Karakoram and the Salt Range region, stimulates the history of worldwide geotectonic concepts till the present. The famous textbooks, respectively palaeogeographic/geotectonic basic monographies by Suess, Neumayr, Uhlig, Kossmath and Kober could not have been compiled without the physically tough and strenous field work done by the international community in this unique area.

2. Early Naturalists

In contrast to the biological sciences, as botany and zoology, geology developed relatively late as an independent branch of natural sciences. The decisive impact came from universal naturalists, as e.g. Leopold von Buch and Alexander von Humboldt around the turn of the 18th to the 19th century. Not before the first decades of the 19th century the earth sciences were shaped into an independent science, and soon systematic subdivisions as mineralogy, palaeontology, mining and technological geology, etc. emerged.

Geological investigations on the Subcontinent were started by the British already before 1820 and finally culminated in the establishment of the Geological Survey of

India in Calcutta in 1851. The main background of the early surveys was to receive an overview on economic interesting areas on a global - British Empire-wide - scale. Soon it was recognized that the legendary fortune of the maharajahs was mostly based on mineral wealth of their kingdoms. From this point of view it is understood, that the colonial authorities showed a strong interest in the reports of travellers who were especially skilled in natural sciences.

The monographs by Tieffenthaler and Baron Hügel concentrating on other topics contain also geological informations. Though the main interest of Honigberger lies in the application of various plants and herbs in pharmacology, he also deals extensively with the mode of applications of various mineral substances. The goal of his investigations was aimed at a better understanding of oriental medicine as performed by the population and by the physicians in the bazaars of Lahore.

Joseph Tieffenthaler

Born April 27, 1710 in Bozen / Bolzano, Tyrol; died July 4, 1785 in Lucknow, India.

Jesuit missionary, since 1743 in India, rector of Agra College, author of the opus „Historisch-geographische Beschreibung von Hindustan" (1785-1788, 3-volumes). For generations this manual was the authentic text on the Subcontinent and Tieffenthaler was considered „the father of modern Indian geography".

The earliest scattered notes on the geology of Pakistan - written by an Austrian - are included in his above mentioned opus magnum. His original manuscript was written in Latin, entitled „Descriptio Indiae". Johann Bernoulli from the Royal Academy of Sciences in Berlin recognized the value of this text and arranged a translation into German. He carefully reviewed and finally edited this manual in 3 volumes. The editorial of Bernoulli was so careful, that he changed the phonetic transcription of many topographical names from „incorrect provincial Tyrolian spelling" into High German. Even the original spelling of the surname Tieffentaller was „improved".

Possibly because of Tieffenthaler's vivid description everybody in German speaking countries still considers Kashmir being „paradise on earth". He reports on the view of the Brahmans, that the alluvial plains of Kashmir, embedded between spectacular beautiful high mountains, represent sediments of a former vast lake, which was consequently drained due to tectonic activities. He also quotes the opinion of the learned Bernier, who travelled in Kashmir during Aorangsebs period, that - as a consequence of frequent earthquakes - a large gullet opened, which swallowed this lake. Also mining of onyx in the Kashmir mountains is mentioned. And among other wonders of nature he reports about the spring called Barari Sindh, three days distant from Kashmir (= Srinagar), which during 14 days in May boils three times per day.

The salt mines are listed, e.g. Miani 70 miles west of Lahore being the most important one and also the sites of salt trade.

And, last but not least, based on old travel reports and narrations of the natives,

Tieffenthaler provides a concise description of the Himalayas, including Tibet s.str. and „western Tibet", i.e. the environments and surroundings of Kashmir.

Baron Karl Alexander Anselm von Hügel

Born April 25, 1795 in Regensburg/Bavaria; died June 2, 1870 in Brussels. (Text-Fig.1)

Wealthy Austrian officer and diplomat. Since 1824 independent scholar engaged with intensive studies of natural sciences and preparation for exploring expeditions. The most important expedition started on October 13, 1835 from Simla to Kashmir. He crossed the Pir-Panjal to Srinagar, visited the Kashmir basin, Lake Wular, Banderpur pass and left Kashmir end of 1835 via the Baramulla pass with tremendous rich (mostly botanical) collections. His major and richly illustrated work is entitled „Kashmir und das Reich der Siek" in four volumes (1840-1848), a shortened version was published in English language.

Already in his paper published in 1836 Baron Hügel is full of admiration: „Nature has done much for Kashmir, art more; the whole valley is like a nobleman's park ...". About decoration stone: „Korán Pandan, near Islámabád, Anatnagh of old, is not only the largest ruin of Kashmir, but one of the splendid ruins of the world: - noble proportions; - material black marble". And: „The only trace of fossil remains in the valley is in a limestone, which contains small shells". Finally: „The burning gases at Jwalamuki are of a very extraordinary nature, nothing of sulphur or naphtha in them. They have a most delicious smell, something like a French perfume with ambergris".

Concerning the minerals of Kashmir Hügel (1840-1848) mentions iron, lead, copper, limestone and graphite (on the Pir-Panjal). Also sulphurous springs are recorded, however, rock-sulphur is unknown. And - like Tieffenthaler - also von Hügel records the frequency of earthquakes and discusses the genesis of the flat plains of the Kashmir valley.

It should be also mentioned, that Volume IV, Part 2 of this fine illustrated monography, comprises articles on various subjects, such as astrology of the Hindus (by v. Hügel), on Bactric coins (v. Arneth), fishes (Heckel), insects (Kollar & Redtenbacher) and mammals (Wagner), however, geology unfortunately is missing.

Finally Baron Hügel (1851, 1852) presented the results of his research on the area between Cabul and the Nanga Parbat, including the Hindukush (Lapis Lazuli-mines) and Chitral / Gilgit / Hunza to the Imperial Academy in Vienna. He also deals with the rock formations of the Salt Range and mentiones the earthquakes in the western Panjab. Concerning the Salt Range he describes the variegated rock formations, comprising red, yellow and green beds, which consist in part of sandstone. The caprock shows (lateritic) red ferrugineous earths, partly endurated to hard stone due to silicification. Plate 1 of Hügel's 1851 paper shows a fine lithographic map of eastern Afghanistan reaching in the east to Hunza respectively Lahore.

Johann Martin Honigberger

Born March 10, 1795 in Kronstadt, Transilvania; died December 18, 1869 in Kronstadt. (Text-Fig. 2)

Pharmaceutist, served as physician at the court of Ranjeet Singh in Lahore. His in part queer, but very interesting and entertaining book entitled „Fruits of the Orient ..." deals extensively with medical experiences. His restless experiments represent somehow a fascinating combination of quackery and serious empiric research. Part of this book can serve as a basis for a pharmacological lexicon and is entitled „Materia medica". From the geological point of view very interesting informations on the occurence and usage of various minerals and rocks in popular medicine are reported. He gives an account on a large variety of locally mined and also on imported officinal mineral substances available in the bazaars and chemist's shops of Lahore. For instance about Asphaltum penjabinum, which is used against blow injuries (probably similar as Ichthyol in Tyrol/Austria). Lapis lazuli is used by the hakims against leprosy, however, the ground mineral - called ultramarine - is used exclusively as a pigment for painting. He also deals with the healing power of sulphur springs in the Panjab. Fine ground gypsum „Setseladyit" is sold by the sadhus in Lahore for treating blear-eyes and colics. „Sahansebed" is the name for ferric oxydic alumina, which - consumed in small pieces - is considered to cure dysentery, a.o. diseases. And „Seng e Basri" is sold by the druggists in Lahore as remedy against epidemic cholera. The chemical analysis in the laboratories of the Theresianum in Vienna showed for the latter a similar composition as diorite, namely magnesia, alumina, silica and ferric oxyde and therefore represents probably a grinding product of the former.

3. The Geological Survey of India and the Relations to Austria

The British - as the leading world and industrial power - started geological basic research on a professional level on the Subcontinent already before 1820. Around the middle of the 19th century the first Geological Surveys of the world have been established. The Geological Survey of India belongs to the most traditional institutions in the world and was established in 1851 in Calcutta. The main aim was to obtain as much information as possible on the mineral wealth of the Subcontinent with the goal to establish the infrastructure for economic exploitation and industrial development. During the first years prospecting for coal was the first aim. As a result railways were introduced as early as 1853! Subsequently a systematic geological survey of British India - with special examination of areas of immediate interest - was commenced. The determining factors in selecting areas for investigation were the likelihood of discovering mineral deposits. Field work was, however, strongly hampered by several factors, such as time consuming accessibility from the headquarters at Calcutta, the lack of suitable topographical maps, insufficient state of telecommunication (telegraph) in remote areas and last but not least by immense health hazards (malaria, a.o. diseases). concerning means of transport Auden et al. (1951) state: „ .... the Geological Survey built up its own herd of elephants, officers setting out from Calcutta by road with their baggage on elephants and themselves mounted either on elephants or on horses. In fact tradition has it that some of these

elephants were trained to pick up pieces of rock and hand them up to the master for his inspection."

The almost 150 years long history of Geological Survey of India is a story of success! The Geological Survey of Pakistan in Quetta continues this great tradition.

The contribution of „Austrian" professional geoscientists to the geological research in Pakistan started as early as 1862, when Ferdinand Stoliczka, member of the Austrian Geological Survey was recruited as palaeontologist by Thomas Oldham, Superintendent of the Geological Survey of India. In the sequel several prominent members of the Austrian Geological Survey joined the Geological Survey of India (Waagen, Griesbach, Feistmantel). All of them contributed enormously to the geological knowledge of the Subcontinent. The temporary assignment of Carl Diener, a prominent member of the University of Vienna, was invaluable for the Mesozoic stratigraphy of the Himalayas.

In the following paragraphs the most outstanding persons should be briefly dealt. Open-minded scientists as Thomas Oldham and his distinguished colleagues in Calcutta or his likeminded counterparts in Vienna (Wilhelm von Haidinger, Franz von Hauer, Eduard Suess, a.o.) prepared the ground for an exceptionally successful cooperation between British and Austrian geo-scientists on the Subcontinent.

Ferdinand Stoliczka - Founder of Systematic Geology of the Western Himalaya/Kashmir

Born July 7, 1838 at Hochwalt (Bilany near Kremsier/Kromeriz) in Moravia (at this time part of the Austrian-Hungarian Monarchy), died June 19, 1874 at Murghi in Ladakh. (Text-Fig. 3)

Without doubt Ferdinand Stoliczka (Text-Fig. 1) ranks among the greatest explorers of the Himalaya region. After his geology studies in Vienna and Tübingen he joined the Austrian Geological Survey. Eduard Suess personally recommended Stoliczka to Thomas Oldham (first Superintendent of Geological Survey of India), who was looking for an experienced and ambitious palaeontologist during a visit to Vienna. From 1862 till his early death in 1874 Stoliczka served as palaeontologist and explorer in the Geological Survey of India.

According to his colleague and early biographer Ball (1886), Stoliczka must have been a very active person with a touch of genius. This high esteem is confirmed also by the tremendous list of his publications, as compiled in a more recent biography (Kolmas 1982).

Immediately after his arrival in Calcutta Stoliczka started to work on his palaeontological opus magnum, the Cretaceous Fauna of Southern India, which when completed in 1873, comprised 1454 pages and 176 lithographic plates.

In 1864 Stoliczka made his first expedition to the Western Himalayas, together with his colleague Frederick Richard Mallet from the Geological Survey of India. Stoliczka

avoided detailed studies, but made traverses over enormous distances. This made him recognize the essential stratigraphic and tectonic features of a region and gave him a general understanding. As a consequence of this method, which was also used by certain Alpine geologists, he was soon able to term the most important formations in the Pir Panjal Range and surroundings and to assess the basic stratigraphy and tectonics. He introduced the term Central Gneiss for what he regarded as the main axis of the North-West Himalaya. Stoliczka's (1866a) paper on this expedition is considered as a splendid example of pioneering, comprising coloured sections across the western Himalaya and several fossil plates.

During his second expedition in 1865 Stoliczka visited also Kashmir, however, his main goal was situated more to the northwest of the first expedition. Among other discoveries, he described the Nummulitic Beds of the Indus Valley in Ladakh and Triassic fossils from Ladakh and from the upper Sindh Valley in Kashmir (Stoliczka 1866b).

The results of his third big expedition, called „Second Yarkand Mission" in 1873/1874 were published by Ball (1886). The route of this expedition does not touch the territory of Pakistan. On the return journey Stoliczka died at Murghi in Ladakh. His grave in Leh is still a pilgrim place for naturalists and Himalaya researchers.

Regarding the palaeontology of Pakistan, his paper on Tertiary crabs from Cutch is worth mentioning (Stoliczka 1871).

Wilhelm Waagen - Palaeontology of Cutch - Salt Range - Hazara

Born June 23, 1841 in Munich, died March 24, 1900 in Vienna. Educated in Bavaria, joined the Austrian Geological Survey. (Text-Fig. 4)

For years Wilhelm Waagen was as palaeontology assistant a coworker of Stoliczka. He joined the Geological Survey of India in 1870 and was appointed palaeontologist in 1875. However, due to poor health he had to resign in the same year and later became Professor of Palaeontology at the University of Vienna. Waagen can be considered as pioneer on the palaeontology and stratigraphy of Cutch, as first authority on the Salt Range (together with his fellow Wynne) and also on the Hazara Hills in the western Himalayas.

His first richly illustrated monography on the Subcontinent deals with the Jurassic Cephalopoda of Kutch (= Cutch, Waagen 1873-1875). And between 1879 and 1895 Waagen published his opus magnum „Salt Range Fossils" comprising approximately 1000 text pages and 128 plates with fossils. His son Lukas Waagen (1900), Edmund von Mojsisovics (1872) and Karl Redlich (1899) contributed also very important supplements to the „Salt Range Fossils". With its magnificent sections unobscured by tropical vegetation, its succession of richly fossiliferous formations starting in the Cambrian, the Salt Range represents a world-famous attraction for geologists. Up to the present the Salt Range sections attract researchers from many different points of view (e.g. Schönlaub 1996).

Another early paper by Waagen & Wynne 1872 documents the Mesozoic sequence of Mount Sirban in Hazara south of Abbottabad. The comparison with Alpine sequences in Austria and Spiti sequence, as documented by Stoliczka, clearly demonstrates the close resemblance of the western Himalayas with the Austrian Alps.

Waagen (1879) deals again with the stratigraphic age of the Attock Slates in Hazara, which - based on scarce fossil findings in other regions - are considered as belonging very likely to the Carboniferous period. In this paper also the stratigraphic riddle of the Tanol Series in the northern part of Hazara is disputed. Based on lithological comparison with strata of the Central Himalayas Waagen considers the Tanol Series as Silurian, which in Hazara are overthrown and faulted against the Attock Slates. The age of the Tanol was in discussion up to the last decades (e.g. Fuchs 1975), and is now assigned to Precambrian.

The contribution by Waagen (e.g. 1887) to questions of the late Palaeozoic glaciation of the Subcontinent also has to be mentioned. He was severely attacked by Feistmantel, who contested Waagen's views.

Ottokar Feistmantel - Palaeobotany and Gondwana

Born November 21, 1848 in Althütten, Bohemia, died February 10, 1891 in Prague.

The Bohemian palaeobotanist Ottokar Feistmantel joined the Geological Survey of India in 1875. The topic of his work was to describe the rich palaeofloras of the Subcontinent, which were collected mainly in coal deposits of Palaeozoic to Tertiary age. His first monographic paper deals with the Jurassic (Oolithic) flora of Kach (= Cutch, Feistmantel 1876). Feistmantel's main merit was the description and especially the palaeogeographic evaluation of late Palaeozoic floras of the Subcontinent („Gondwana"-Flora) and the comparison with age-equivalent palaeofloras in Australia, Madagascar, Africa and South America, which led to the conception of Gondwanaland (Eduard Suess 1885). The results of his palaeofloristic studies are presented in four volumes of Palaeontologica Indica (1876-1886), comprising almost 200 lithographic plates with plant fossils, and in numerous other publications. Also his paper on fragments of a palm leaf from the Miocene near Chakoti in the Jhelam Valley (Feistmantel 1882) is worth mentioning.

Carl Ludolf Griesbach - Superintendent of the Geological Survey of India

Born December 11, 1847 in Vienna, died April 13, 1907 in Graz. (Text-Fig. 5)

In the time span between 1878 - when Griesbach joined the Geological Survey of India - and 1894 - when he became the fourth Superintendent (after Oldham, Medlicott and King) - he did extraordinary hard and successful field work in the Central Himalayas, in Afghanistan, Turkestan, Khorassan and in Pakistan (Baluchistan and Hindu Kush). Moreover, Griesbach served in the British army and joined several military expeditions as highly decorated officer and geologist. For

years geological field programmes in the areas along the Afghan boundary - as in the North-West Frontier Province and in Baluchistan - were not possible owing to disturbed political conditions. Griesbach was a superb draughtsman and illustrated all his papers with excellent lithographs by himself. This versatility enabled him to carry out geological field work, profile drawing and sketching even during several military expeditions.

In 1880 Griesbach concluded, that Zanskar and the Pir Panjal in Kashmir are offshoots of the Himalaya proper and that the gneissic rocks of Kailas extend to Dardistan, Chilas and Mustagh.

Several of his papers deal with the geology of Baluchistan. In 1881 his basic paper on the surroundings of the Bolan pass, comprising a geological map 1:500.000 appeared. During his work with the Afghan Boundary Commission, he worked also in the area around Quetta (Griesbach 1885). In the famous paper by Griesbach (1893a) the impact of the catastrophic earthquake in Baluchistan on 20th December 1892 was recorded and documented with photographs. Already Oldham has installed an earthquake monitoring programme. As a consequence, the Subcontinent shows the longest tradition of seismographic records in the World. Another key-paper deals with the area between Chappar Rift and Harnai in Baluchistan, comprising a geological map 1:125.000 (Griesbach 1893b).

In the course of the publication of his „Field-notes" in the Records of the Geological Survey of India, Griesbach (1887a) also investigated the Hindu Kush and Kafiristan towards the south to Peshawar. Also these investigations were carried out during his acitivity with the Afghan Boundary Commission and are summarized in his paper in 1887b. The attached coloured geological map shows the surroundings of Quetta towards the Indus river and northwards to the area of Dera Ismail Khan.

Griesbach's (1891) paper on the Geology of the Central Himalaya is considered as his most important scientific work, which received international interest and his fossil collections - after preliminary inspection in Austria - stimulated the great Indian-Austrian Himalaya Expedition in 1892 (see Diener).

From 1894 till 1903 Griesbach was Superintendent of the Geological Survey of India. During his directorship the exploration for mineral raw materials, as coal, oil and other economic minerals was intensified. Special posts for specialist in coal mining and in gold mining were introduced, and in 1902 the mining branch of the Survey was transferred to the newly created department of the „Bureau of Mines Inspection", later on named „Department of Mines". Griesbach also started to increase the water supply in various provinces by means of artesian borings. His proposal to shift the headquarters of the Survey to a hill station unfortunately was not accepted by the Government (Auden et al. 1951).

Carl Diener - Triassic Ammonite Stratigraphy of the Himalayas

Born December 11, 1862 in Vienna; died January 6, 1928 in Vienna. (Text-Fig. 6)

In the second half of the 19th century, Vienna without doubt can be considered as the centre of Mesozoic Tethyan palaeontology and biostratigraphy. This was certainly the reason, why William King, Superintendent of the Geological Survey of India, asked the famous Professor Eduard Suess for assistance in determination and stratigraphic evaluation of the rich Himalayan fossil collections, collected by Griesbach and other members of the Geological Survey of India. The fossils were shipped to Vienna and after a preliminary inspection by Diener and other palaeontologists, the material was found to be of outstanding interest for further intensive studies. On Suess's suggestion, the Austrian Imperial Academy of Sciences proposed to the Indian government a joint expedition to the most promising sites of Triassic ammonites, which are situated in Kashmir, as well as in the Indian part of the Himalayas. Finally in 1892 an extraordinary successful expedition to the Western Himalays took place with Griesbach and Middlemiss as members of the Geological Survey of India and Diener as delegate of the Austrian Imperial Academy of Sciences. The outstanding results of this expedition were laid down by Diener and other palaeontologists in a number of excellent papers, mostly in Palaeontologica India. Up to the present these monographies represent the standard papers for Triassic Himalayan stratigraphy (e.g. Diener 1899a, b; 1912, 1913, 1915). Alexander Bittner (1899) dealt with the brachiopoda and lamellibranchiata and Edmund von Mojsisovics (1896) with part of the ammonites.

Another important paper by Diener (1906) describes Upper Triassic ammonites from Baluchistan, which were collected by Vredenburg.

Based mostly on the studies in the Alps and in the Himalayas, Mojsisovics, Waagen & Diener (1895) and Diener (1915b) were in the position to attempt a global palaeogeographic synthesis on the distribution of the marine Triassic. Their conclusions, with some modifications, are valid up to the present.

Moreover, it should be reminded, that the basal Triassic stages were called by the international scientific community after their great protagonists „Griesbachian" and „Dienerian", in order to honour their outstanding contribution towards Mesozoic Himalayan geology.

4. Post World War II activities

Geological investigations in Pakistan during the last 50 years are characterized by basic research in connection with mountain climbing and geoscientific oriented expeditions in the northern provinces, and by applied research by consulting offices respectively exploration companies (e.g. AUSTROMINERAL, OMV). The most important results of research are documented in numerous publications and several geological maps e.g. by Gattinger, Fuchs, Gamerith and Buchroithner. Stratigraphical and palaeontological research on material from Pakistan was performed by colleagues from various Austrian institutions, e.g. by Flügel, Schouppé, Kahler, Mostler and Vogeltanz. Last but not least, post-graduate geoscientists from Pakistan have been trained from 1964-1970 in Austria.

Gasherbrum II - First Ascent

(Text-Fig. 7)
Traugott Erich Gattinger was geologist of the „Austrian Himalaya-Karakoram-Expedition 1956", led by Fritz Moravec. The goal of the expedition was the first ascent to Gasherbrum II (8035 m) and it was successful. According to Gattinger (1961) the Karakoram must be considered as separate geological system, intermediate between the Variscan Pamir System and the Alpine Himalaya System. The above cited well illustrated publication gives a cross section and a geological map of the Gasherbrum group in the central Karakoram between the Indus at Skardu and the Shaksgam river. Gattinger distinguished several tectonic units and his paper is still remembered in one breath with the pioneering studies on the Karakoram by the famous Italian Desio, the German H.J. Schneider and with following Japanese studies.

Field work in Chitral and Gilgit

Between 1965 and 1975 Herfried Gamerith and Manfred Buchroithner spent several extensive visits to the region of the central and eastern Hindu Kush in Chitral and extended their field campaigns also eastwards to Gilgit province. The results of their field studies are documented in a set of papers and impressive geological maps (e.g. Buchroithner 1980, Buchroithner & Gamerith 1978, 1986, Buchroithner & Scharbert 1979, Gamerith 1972, 1979, 1990, Gamerith & Kolmer 1973, 1975, Gratzl (Ed.) 1972, Senarclens de Grancy (Ed.) 1991). Though Buchroithner's work was concentrated on the Warkhan, including the Pamir, he extended his field work also to the Hindu Kush in Pakistan and especially produced geological maps by new sophisticated methods. He evaluated Landsat MSS imageries, terrestrial-photogrammetric colour photographs and aerial photographs for structural interpretations and like Gamerith 1990 he was also able to show, that economic valuable mineralizations and hot springs are often located at intersections of major faults. He was also successful in distinguishing various lithological units by means of a computer image analyzer programme.

Gamerith (in Gratzl [Ed.] 1972) compiled a geological review map on the area between Tirich Mir and Kampire Dior (Chitral and Gilgit provinces). Gamerith 1979 published a privately edited coloured „Geological Map of Gilgit / Chitral / Wakhan 1:250.000", which provides an excellent review on a touristic key area of Pakistan. An updated edition of this excellent map on a more recent topography is highly recommended for publication! Mapsheet Shoghor 1:25.000 comprises roughly the area north of Chitral town and south of Arkari close to Tirich Mir (Gamerith 1990). From the technical point of view the finest example of a coloured geological map was prepared by Buchroithner (Buchroithner & Gamerith 1986), entitled „Geological Map of the Tirich Mir (Hindu Kush-Pakistan)" in the scale 1:50.000. The topographical basis was provided by R. Kostka from Institute for Applied Geodesy and Photogrammetry, Technical University of Graz. The evaluation of 200 m contour lines is based on existing topographical maps, aerial photographs and Landsat imageries. The map comprises the area from the Arkari Gol in the west, to the

settlement Kiyar in the south and extends almost to Reshun on the Mastuj river in the east. Tirich Mir is the center of the map. The explanatory notes provide an excellent review on the complex geological setting, including the mineral resources potential of this remote area.

Hazara, Western Himalayas

(Text-Fig. 8)
At present Gerhard Fuchs is the only - though already retired but still very active - member of the Austrian Geological Survey, who continues the tradition of Himalayan research. Part of his studies on the Western Himalaya were carried out in the territory of Pakistan, in particular in Hazara and in the Swabi-Nowshera region west of the Indus river. The results of these studies are summarized in a well-illustrated paper (Fuchs 1975) and are part of the explanatory text of the „Geological-Tectonic Map of the Himalaya" in the scale 1:2 millions (Fuchs 1982). Based on detailed field studies, carried out in the course of the Austrian Geological Himalayan Expedition 1969, Fuchs studied several key sections in the above mentioned area. An attempt is made to correlate the Palaeozoic and Mesozoic sequences of Swabi-Nowshera, Hazara and Kashmir to the Indian Lesser Himalaya.

In Hazara Fuchs distinguishes two subsidiary units, namely the Islamabad Zone with Late Mesozoic to Eocene formations, and the Abbottabad Zone, which overrides the Islamabad Zone on a steep thrust plane. The latter comprises the Hazara Slates, the Tanakki-Sirban sequence, Hazira and Galdanian Formations, and a rich Jurassic to Eocene development. Due to fossil findings in the Hazira Formation it was possible to confirm an Early Cambrian age of this formation (Fuchs & Mostler 1972, Mostler 1990). The Hazara Slates are considered to be equivalents of the Simla Slates, the Tanakki Tillite of the Blainis and the thick carbonate sequence of the Sirban corresponds with the Shalis and Krol.

The detailed studies by Fuchs in Hazara would not have been possible without the friendly assistance by Mir Abdul Latif, who had elaborated a detailed study on the geology of southeastern Hazara during his participation in the courses of the „Post-graduate Training Center for Geology" in Vienna (see chapter 5).

Further Basic Research

The University of Graz can be considered as a stronghold for the study of Palaeozoic corals. In a fundamental paper by Franz Heritsch (1937a) the coral fauna of the Productus Limestone of the Salt Range - which was originally described by Waagen & Wentzel (1887) - has been revised and new taxa are described. Helmuth W. Flügel still continues the tradition established by Heritsch. Permian Rugosa from the Karakoram region (Flügel 1989, 1990, 1995; Flügel & Gaetani 1991), from Chitral (Flügel 1994, Schouppé 1965) and from the Salt Range (Flügel 1970) were studied and additional new taxa have been described.

Also Herfried Mostler at the University of Innsbruck dealt extensively with

stratigraphic questions, e.g. with the age of the Hazira Formation in Hazara (Fuchs & Mostler 1972, Mostler 1980), which he considers of Lower Cambrian age. Kozur & Mostler 1976 described a new conodont taxon from the Mianwali Formation from Nammal/Salt Range.

Rudolf Vogeltanz, palaeontologist at Natural History Museum in Salzburg, described a rare finding of a problematic fossil from the Devonian of Owir An in Tirich Mir area, Chitral (Vogeltanz 1969, Vogeltanz & Diemberger-Sironi 1968), collected by Kurt Diemberger during the Austrian Hindukush Expedition in 1967 (Diemberger 1968).

Franz Kahler, well known specialist on late Palaeozoic fusulinids included also the findings in Pakistan in his palaeogeographic studies (e.g. Kahler 1976, 1982).

In the frame of the stratigraphic correlation and the marine and non-marine sediment distribution analysis of the „Neogene of the Mediterranean Tethys and Paratethys" (Steininger et al. [Eds.] 1986) also the Baluchistan Basin and the Lower and Upper Indus Basins and Kashmir were included in the compilation. They are the easternmost extension of this sedimentary realm.

The Austrian Karakoram-Expedition 1958 was dedicated to geomorphological studies with special emphasis on the glaciation of the Haramosh, Gilgit, Rakaposhi Range (e.g. Wiche 1958, 1962).

Mineral Exploration

(Text-Fig. 9)
In 1960/1970 AUSTROMINERAL Co. Ltd. carried out a mineral survey in Chitral. The results are mostly documented in unpublished reports by D. Briegleb, A. Egger, H. Gamerith, W. Paar, P. Steiner, and W.L. Werneck. Gamerith 1990, however, summarized the results of exploration activities on the Awireth Gold Deposit and the Krinj Antimony Mine in northwest Chitral. Both mineral deposits are situated on the Geological Map Sheet Shogor 1:25.000, which represents also a result of this field campaign. In addition, metallogenetic aspects of scheelite mineralizations west of Tirich Mir and of molybdenite outcrops (e.g. at Shah Jinali Gol) are discussed. In Awireth the gold occurs as late hydrothermal phase in both boulangerite and pyrite. The Sb-Pb-Au-Ag-mineralization is controlled by the main fault between the Cretaceous to Tertiary Shogor Limestone and Upper Palaeozoic Awireth Series. Along this fault a strongly fractured „contact dolomite" occurs, which represented the preferred migration path for ascending hydrothermal solutions. However, for an economic exploitation the reserves evidently are too small. The antimony mineralization at Krinj extends over a distance of at least 2 kilometers between the Luthkho and Bokhtul Valley along a narrow zone within the Cretaceaus to Tertiary Chitral Slates, immediately below the contact to the Shogor Limestone. With proven reserves of close to 3000 t of ore averaging 15-20 % Sb, the Krinj mineralization can be classified as a medium-size antimony deposit.

Gamerith & Kolmer 1975 also investigated limestones and dolomites in the area between Chitral and Gilgit (Buni Zom, Das Bar-valley) in respect to their trace

element content. However, no indications for any economic mineralizations have been detected.

Hydrocarbon Exploration

In 1993 OMV Pakistan Exploration Co. Ltd. in cooperation with Hardy Oil & Gas (UK), Pakistan Petroleum Ltd. and Oil & Gas Development Corporation Pakistan drilled Miano-1 borehole in Sindh desert for hydrocarbons. At a depth of 3890 m massive indications for gas occurred in a sandstone horizon. Borehole tests showed excellent gas flux with gas rates up to 1 million m^3 per day (Hamilton 1993). Up to present OMV Pakistan is active in the exploration for hydrocarbons, also in other parts of Pakistan.

Based on data achieved during hydrocarbon exploration Wolfgang Frisch et al. (in Jadoon et al. 1997) discuss a new model of the tectonic evolution of North Potwar deformed zone in the Himalayan foreland. The authors arrive at the conclusion, that the timing of Siwalik sedimentation and thrusting indicate sedimentation partly simultaneous to thrusting. The possibility of piggyback thrusting is considered. Recent discoveries of oil have established hydrocarbon potential of this tectonic zone (The Khaur anticline in North Potwar was drilled in 1914 and proved to be the first commercial oil discovery on the Subcontinent).

Hot Springs

In his papers on hot springs in the eastern Wakhan Buchroithner (1978b, 1981) also refers to the thermal spa of Garam Chesma in Luthko Valley in Chitral, which serves as remedy for skin diseases. A close genetic connection of the hot springs with tectonic lineaments respectively intersections of tectonic lines is evident. Moreover, the hot springs are all situated more or less at the boundaries of plutons (Buchroithner & Gamerith 1978). Buchroithner 1981 states; „The thermal springs are the results of deeply circulating, locally derived meteoric water that has percolated through the fractured granitic plutons and the surrounding wall rocks to the depth of some thousand meters, became heated due to the geothermal gradient and found access to the surface along fractured and faulted zones. On its way upwards, however, it mixed with cold water from shallower ground water levels ... It results in springs which may have temperatures ranging from very low to almost boiling ... Besides, earthquakes might influence the flow rate." These hot springs - besides being locally used as spas - may have potential for limited power generation as well as for geothermal space heating and agricultural uses in the remote areas of mountainous northern Pakistan.

Neotectonics

Adrian E. Scheidegger (1979) studied the neotectonics of the Western Himalaya region of Jammu, Kashmir and Ladakh. He arrives at the conclusion, that the orientation of joints and river valley trends shows a substantial correlation. „The

orientation of the neotectonic stress field deduced from joint-orientation measurements is in good conformity with the ideas of plate tectonics". And: „evidence from earthquakes... imply a regional N-S compression. This can be interpreted in terms of a subduction zone present in this region".

5. Post-graduate Training Center for Geology

Following a suggestion by UNESCO, Austrian authorities established a Post-graduate Training Center for Geology in Vienna on the basis of a cooperation between the Geological Survey of Austria with the University of Vienna. From 1964/65 until 1969/70 in six courses 86 post-graduate geoscientists from developing countries received special training. The fellowships comprised an 8 months stay in Austria and offered a large set of scientific programmes, as excursions, practical studies, teaching and supervised academic work. The courses were financed by the Austrian government, the travelling costs were granted by UNESCO and O.A.S. Most participants used the opportunity to work out reports or publications on material from their native countries on a high professional level. An overview on this successful project is given by Küpper 1970.

Out of the 86 participants seven scientists from Pakistan took part in the courses and improved their knowledge in various branches of academic and applied geoscientific work. Last, but not least, several of them developed long lasting connections and friendship with their Austrian advisers and some even achieved an additional academic degree in Austria. The Austrian geoscientists are proud, that the following colleagues from Pakistan - some of them famous on an international scale - took part in these training courses: S.M. Akthar (geology, petrology), N.H. Bokhari (foraminifera), U.Z. Bilal Ul Haq (micro/nannofossils), S.A. Ikram-Uddin (palynology), M.A. Latif (geology, micropalaeontology), A. Riaz (micropalaeontology), A. Ullah Khan (foraminifera).

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Selected References

AHMAD, Z.: Bibliography and Index of the Geological Survey of Pakistan Reports (unpublished).-Records Geol. Survey Pakistan, 42, 39 p., Quetta 1978.

AUDEN, J.B., GHOSH, P.K., GHOSH, A.M.N. & JHINGRAN, A.G.: Centenary of the

Geological Survey of India 1851-1951. A short history of the first hundred years.-122 p., illus., Calcutta (Geolog. Survey) 1951.

BALL, V.: Scientific Results of the Second Yarkand Mission; Memoir of the Life and Work of Ferdinand Stoliczka, PH.D., Palaeontologist of the Geological Survey of India from 1862 to 1874.- 36 p., London (Eyre & Spottiswoode) 1886.

BLANFORD, H.F. & STOLICZKA, F.: Catalogue of the specimens of meteoric stones and meteoric irons in the Museum of the Asiatic Society of Bengal, Calcutta, corrected up to January 1866.- Jour. Asiatic Soc. Bengal, 35, pt. II, 43-45, Calcutta 1866.

BORTENSCHLAGER, S. & PATZELT, G.: Das Pollendiagramm vom Kol-e Ptukh (3272 m) im östlichen Wakhan.- In: SENARCLENS DE GRANCY, R. & KOSTKA, R. (Eds.): Großer Pamir, 183-200, Graz (Akadem. Druck- und Verlagsanst.) 1978.

BUCHROITHNER, M.F.: Zur Geologie des Afghanischen Pamir.- In: SENARCLENS DE GRANCY, R. & KOSTKA, R. (Eds.): Großer Pamir, 85-118, 6 Text-Figs., 2 Tab., Graz (Akadem. Druck- und Verlagsanst.) 1978a.

BUCHROITHNER, M.F.: Ein Beitrag zu den Thermen des östlichen Wakhan.- In: SENARCLENS DE GRANCY, R. & KOSTKA, R. (Eds.): Großer Pamir, 151-165, 4 Text-Figs., 3 Tab., 2 geol. Maps, Graz (Akadem. Druck- und Verlagsanst.) 1978b.

BUCHROITHNER, M.F.: An outline of the geology of the Afghan Pamirs.- Tectonophysics, 62, 13-35, 8 Text-Figs., 2 Tabs., Amsterdam 1980.

BUCHROITHNER, M.F.: Geological Setting and Chemical Geothermometry of some Hot Springs in the Wakhan (NE Afghanistan).- Verh. Geol. B.-A., 19-29, 2 Text-Figs., 3 Tab., Wien 1981.

BUCHROITHNER, M.F. & GAMERITH, H.: Pamir-e Wakhan - Dardistan. Geological map of Selsela Koh-e Wakhan (Pamir-e Wakhan) and parts of the High Hindu Kush, Hinduraj and Western Karakoram. Scale 1:250.000.- Enclosure in SENARCLENS DE GRANCY, R. & KOSTKA, R. (Eds.): Großer Pamir, Graz 1978.

BUCHROITHNER, M.F. & GAMERITH, H.: On the Geology of the Tirich Mir Area, Central Hindu Kush (Pakistan).- Jb. Geol. B.-A., 128, 367-381, 9 Text-Figs., 1 Map, Wien 1986.

BUCHROITHNER, M.F. & KOLMER, H.: Notes on the Wakhan Formation of the Great Afghan Pamir and the Eastern Hindu Kush.- Afghanistan J., 6, 2, 54-61, Graz 1979.

BUCHROITHNER, M.F. & SCHARBERT, S.M.: Geochronological data from the Great Afghan Pamir and the Eastern Hindu Kush.- N.Jb.Geol.Paläont.Mh., 449-456, 2 Text-Figs., 3 Tab., Stuttgart 1979.

DIEMBERGER, K.: Ein Apfel auf dem Tirich Mir (Reisebericht der Österreichischen Hindukusch-Kundfahrt 1967. 3. Geologische Ergebnisse).- Jb. Österr. und Deutscher Alpenverein, 93, 143-147, Innsbruck 1968.

DIENER, C.: Anthracolithic fossils of Kashmir and Spiti.- Himalayan Fossils, Mem. Geol. Survey India, Palaeont. Indica, Ser. 15, Vol. 1, Pt. 2, 95 p., 8 Pls., Calcutta 1899.

DIENER, C.: Notes on an Upper Triassic fauna from the Pishin District, Baluchistan, collected by E. Vredenburg in the year 1901.- Records Geol. Survey India, 34, 12-21, Calcutta 1906.

DIENER, C.: Über die Konstanz einiger Hauptgrenzen der marinen mesozoischen Reiche.- Mitt. Geol. Ges. Wien, 5, 13-19, Wien 1912.

DIENER, C.: Triassic faunae of Kashmir.- Mem.Geol.Surv. India, Palaeont. Indica, 5, 1, 1-133, 13 Pls., Calcutta 1913.

DIENER, C.: The anthracolithic faunae of Kashmir, Kanaur and Spiti.- Mem.Geol. Surv. India, Palaeont. Indica, 5,2, 1-135, 11 Pls., Calcutta 1915 a.

DIENER, C.: Die marinen Reiche der Triasperiode.- Denkschr.kais.Akad.Wiss., mathem.-naturw.Kl., 92, 405-549, 1 map, Wien 1915 b.

FEISTMANTEL, O.: Note on remains of palm leaves from the (Tertiary) Murree and Kasauli Beds in India.- Rec.Geol. Survey India, 15, 1, 51-54, Calcutta 1879.

FEISTMANTEL, O.: Über die pflanzen- und kohlenführenden Schichten in Indien (beziehungsweise Asien), Afrika und Australien und darin vorkommende glaciale Erscheinungen.- Sitzber.k.böhm.Ges.Wiss., 1-102, Prag 1887.

FEISTMANTEL, O.: Jurassic (Oolitic) Flora of Kach.- Mem.Geol. Survey India, Palaeont. Indica, Ser. XI, Vol. II, Pt. I, 1-80, Text-Figs., Tabs., 12 Pls., Calcutta 1880.

FLÜGEL, H.W.: Die Entwicklung der rugosen Korallen im hohen Perm.- Verh.Geol. B.-A., 146-161, 3 Tab., Wien 1970.

FLÜGEL, H.W.: Vorläufige Mitteilung über permische Korallen aus dem Nord-Karakorum.-Anz.Österr.Akad.Wiss., mathem.-naturw.Kl., 126, p.121, Wien 1989.

FLÜGEL, H.W.: Rugosa aus dem Perm des N-Karakorum und der Aghil-Kette.-

Geol.Paläont.Mitt. Innsbruck, 17, 101-117, 2 Text-Figs., 5 Pl., 1 Tab., Innsbruck 1990.

FLÜGEL, H.W.: Korallen aus dem Unter-Perm von Chitral (NW-Pakistan): Vorbericht.- Anz.Österr.Akad.Wiss., mathem.-naturw.Kl., 130, p. 47, Wien 1994.

FLÜGEL, H.W.: *Aphyphyllum* n.sp. (Rugosa) aus der Gircha-Formation (?) des pakistanischen Karakorum.- N.Jb.Geol. Paläont.Mh., 166-172, 2 Text-Figs., Stuttgart 1995.

FLÜGEL, H.W. & GAETANI, M.: Permian Rugosa from Northern Karakorum and Aghil Ranges.- Riv.Ital. Palaeont. 97, 35-48, 5 Text-Figs., Milano 1991.

FUCHS, G.: The Significance of Hazara to Himalayan Geology.- Jb. Geol.B.-A., Sdbd. 15, 21-23, Wien 1970.

FUCHS, G.: Geologie des Himalaja und ihre Probleme.- Jb. Österr. Alpenverein, 197-210, 6 Text-Figs., Innsbruck 1971.

FUCHS, G.: Contributions to the Geology of the North-Western Himalayas.- Abh. Geol. B.-A., 32, 59 p., 64 Text-Figs., 5 pl., Wien 1975.

FUCHS, G.: Traverse of Zanskar from the Indus to the Valley of Kashmir - a preliminary note.- Jb.Geol.B.-A., 120, 219-229, 1 Text-Fig., 1 Plate, Wien 1977.

FUCHS, G.: Geologic-Tectonic Map of the Himalaya 1:2,000.000. With Explanations.- 50 p., 13 Text-Figs., 1 Plate, Vienna (Geol. Survey of Austria) 1982 a.

FUCHS, G.: Explanations of the geologic-tectonic map of the Himalaya.- 50 p., 13 Text-Figs., 1 Plate, Vienna (Geol. Survey of Austria) 1982 b.

FUCHS, G. & GUPTA, V.J.: Palaeozoic Stratigraphy of Kashmir, Kisthwar and Chamba (Panjab Himalayas).- Verh. Geol. B.-A., 68-97, 3 Text-Figs., 1 Plate, Wien 1971.

FUCHS, G. & MOSTLER, H.: Der erste Nachweis von Fossilien (kambrischen Alters) in der Hazira-Formation, Hazara, Pakistan.- Geol.Paläont.Mitt. Innsbruck, 2, 1-12, 4 Text-Figs., Innsbruck 1972.

FULLJAMES, G. & HÜGEL, Karl von: Recent Discovery of Fossil Bones in Perim Island, in the Cambay Gulph.-Jour. Asiatic Soc. Bengal, 5, 288-291, Calcutta 1836.

GAMERITH, H.: Zur Geologie des östlichen Hindukush.- In: GRATZL, K. (Ed.): Hindukusch, 99-110, Text-Figs. 42-44, 1 Tab., Graz (Akadem. Druck- und Verlangsanstalt) 1972.

GAMERITH, H.: Geologische Karte von Gilgit/Chitral/Wakhan (Nordpakistan und Ostafghanistan) 1:250.000.- Private Edition, Graz 1979.

GAMERITH, H.: Antimony, Gold and Polymetallic Deposits of the Awireth-Krinj Area, Chitral/Pakistan.- Mitt.Naturwiss.Ver. Steiermark, 120, 155-156, 1 Text-Fig., 1 geol.map, Graz 1990.

GAMERITH, H. & KOLMER, H.: Untersuchungen an Intrusivgesteinen des östlichen Hindukusch.-Geolog.Rdsch., 62, 161-171, 4 Text-Figs., 3 Tab., Stuttgart 1973.

GAMERITH, H. & KOLMER, H.: Zur Verteilung einiger Spurenelemente in kalkigen und dolomitischen Gesteinen des östlichen Hindukusch.- Mitt.Abt.Geol. Paläont.Bergb. Landesmus. Joanneum, 35, 65-74, 4 Text-Figs., 1 Tab., Graz 1975.

GATTINGER, T.E.: Geologischer Querschnitt des Karakorum vom Indus zum Shaksgam. With Contrib. by H. SCHARBERT.- Jb. Geol. B.-A., Sdbd. 6, 118 p. 31 Text-Figs., 9 Pl., Wien 1961.

GICKLHORN, J. et al.: Österreicher als Erforscher der Erde.- Notring Jahrbuch, 159 p., illustr., Wien 1956.

GRATZL, K. (ed.): Hindukusch.- Graz (Akadem. Druck- u. Verlagsanstalt) 1972.

GRIESBACH, C.L.: Report on the Geology of the Section between the Bolan Pass in Baluchistan and Girishk in Southern Afghanistan.- Mem.Geol.Surv. India, 18, 1-60, 11 Text-Figs., 11 Pls., Calcutta 1881.

GRIESBACH, C.L.: Field-notes from Afghánistán: (No. 4) - from Túrkistán to India.- Records Geol.Surv. India, 20, 17-26, Calcutta 1887a.

GRIESBACH, C.L.: Field-notes: No. 5 - to accompany a Geological Sketch Map of Afghánistán and North-Eastern Khorassan.- Rec.Geol.Surv. India, 20, 93-103, 1 Tab., 1 Map, Calcutta 1887b.

GRIESBACH, C.L.: The geology of the Safed Koh.- Rec.Geol.Surv. India, 25, 2, 59-109, 2 Pls., Calcutta 1892.

GRIESBACH, C.L.: Notes on the earthquake in Baluchistan on the 20th December 1892.- Rec.Geol.Surv. India, 26, 2, 57-61, 3 Pls., Calcutta 1893 a.

GRIESBACH, C.L.: On the Geology of the country between the Chappar Rift and Harnai in Baluchistan.- Rec.Geol. Surv. India, 26, 4, 113-147, 3 Pls., 1 Map, Calcutta 1893 b.

HAIDINGER, W.v.: Dr. F. Stoliczka. Photographie von Simla gesandt.- Jb.Geol.R.-A. Verh., 15, 3, p. 186, Wien 1865.

HAIDINGER, W.v.: Ein Schreiben des Herrn Dr. Ferdinand Stoliczka aus Kaschmir.- Sitzber.kais.Akad.Wiss., mathem.-naturw.Cl., 52, I. Abt., 664-668, Wien 1866.

HAIDINGER, W.v.: Brief von Stoliczka.- Jb.Geol.R.-A., Verh. 13, p. 78, Wien 1863.

HAIDINGER, W.v.: Nachrichten von Th. Oldham und F. Stoliczka aus Calcutta.- Jb. Geol.R.-A., Verh., 14, 100-101, Wien 1864.

HAIDINGER, W.v.: Brief von Dr. Stoliczka aus Simla im Himalaya.- Jb.Geol.R.-A., Verh., 14, 121-122, Wien 1864.

HAIDINGER, W.v.: Dr. F. Stoliczka nach Calcutta zurückgekehrt.- Jb.Geol.R.-A., Verh., 14, 215-216, Wien 1864.

HAMILTON, W.: Pakistanbohrung Miano-1 fündig. Eine Erfolgsstory.- ÖMV-Mix, 2-3, 3 Text-Figs., Wien 1993.

HERITSCH, F.: Korallen aus dem Salt Range, aus Timor und aus Djoulfa.- Sitzber. Akad.Wiss., mathem.-naturw.Kl., Abt. I, 146, 1-16, Wien 1937a.

HERITSCH, F.: Die rugosen Korallen und die Stratigraphie der Permformation.- Mitt. Geol.Ges. Wien (F.E. Sueß-Festschrift), 29, 307-328, Wien 1937b.

HOCHSTETTNER, F. von: Asien, seine Zukunftsbahnen und seine Kohlenschätze.- X+188 p., 1 Map, Wien (A. Hölder) 1876.

HOCHSTETTNER, F. von: Fest-Versammlung zur Feier des fünfundzwanzigjährigen Bestehens der k.k. Geographischen Gesellschaft in Wien am 22. Dezember 1881. Unter dem Vorsitze des Protectors Sr. kaiserlichen und königlichen Hoheit des durchlauchigsten Erzherzogs Kronprinzen Rudolf.- Mitth.k.k.Geograph. Ges. Wien, 25, 1-64, Wien 1882.

HONIGBERGER, J.M.: Früchte aus dem Morgenlande oder Reise-Erlebnisse, nebst naturhistorisch-medizinischen Erfahrungen, einigen hundert erprobten Arzneimitteln und einer neuen Heilart, dem Medial-Systeme.- 590p., 40 lithographed Plates, Wien (Gerold & Sohn) 1851.

HÜGEL, C.v.: Notice of Visit to the Valley of Kashmir in 1836.- Jour.Asiatic Soc. Bengal, 5, 184-187, Calcutta 1836 a.

HÜGEL, C.v.: Notice of a Visit to the Himmáleh Mountains and the Valley of Kashmir, in 1835.- Jour. Royal Geogr.Soc., 6, 343-349, London 1836 b.

HÜGEL, C.v.: Kaschmir und das Reich der Siek.- Vol. I: XIV + 362p., 1840; Vol. II; 478p., 1840; Vol. III: 453p., 1841; Vol. IV, Part 1: 246p., 1848; Vol. IV, Part 2: p. 247-865, Stuttgart (Hallberger'sche Verlagshandlung) 1844. Abundant illustrations.

HÜGEL, K.von: Das Kabul-Becken und die Gebirge zwischen dem Hindu Kosch und der Sutlej. Part 1:- Denkschr.kais.Akad.Wiss., phil.-hist.Cl., Vol. 2, 1. Abth., 119-190, 3 Maps, Wien 1851. Continuation (Part 2: Vol. 3, 1 Abth., 72-112, Wien 1852).

HUSSAIN, F., IQBAL, M.W.A. & ZAKI, A.: Bibliography of the geology of Southern Pakistan.-Records Geol.Surv. Pakistan, 54, 43 p., Quetta 1980.

JADOON, I.A.K., FRISCH, W., KEMAL, A. & JASWAL, T.M.: Thrust geometries and kinematics in the Himalayan foreland (North Potwar deformed zone), North-Pakistan.- Geol.Rundsch., 86, 120-131, 10 Text-Figs., Berlin 1997.

KAHLER, F.: Fortschritte der Fusuliniden-Stratigraphie im Perm Eurasiens.- Zbl. Geol.Paläont. Teil II, Jg. 1975, 171-174, Stuttgart 1976.

KAHLER, F.: Neue Ergebnisse der Fusuliniden-Stratigraphie im Karbon und Perm des Südrandes Asiens (Iran bis Japan).- Zbl.Geol.Paläont. Teil II, 203-216, Stuttgart 1982.

KOLMAS, J.: Ferdinand Stoliczka (1838-1874): The Life and Work of the Czech Explorer in India and High Asia.- Wiener Studien zur Tibetologie und Buddhismuskunde, 9, XI+58 p., Wien 1982.

KOZUR, H. & MOSTLER, H.: Neue Conodonten aus dem Jungpaläozoikum und der Trias.- Geol.Paläont.Mitt. Innsbruck, 6, 3, 1-33, 4 Pls., Innsbruck 1976.

KÜPPER, H. et al.: Geoscience Postgraduates from Developing Countries in Austria. Report on six courses held in Vienna 1964/65 until 1969/70.- 39 p., 7 Text-Figs., 2 Tab., Wien (Geol. B.-A.) 1970.

LENDENFELD, R.v.: Die Hochgebirge der Erde.- XIII + 531 p., 148 Text-Figs., 15 Maps, Freiburg im Breisgau (Herder) 1899.

LYDEKKER, R.: The geology of the Káshmír and Chamba territories, and the British district of Khágán.- Mem.Geol.Surv. India, 22, Calcutta 1883.

MERKL, W. (Ed.): Himalaja-Bibliographie (1801-1933).- Deutsche Himalaja-Expedition 1934 mit Unterstützung des Vereins der Freunde der Alpen-vereinsbücherei, 48 p., München 1934.

MOJSISOVICS, E.v.: Über die Entdeckung von Ammoniten in der carbonischen Formation Indiens.- Verh.k.-k.Geol.R.-A., 314-316, Wien 1872.

MOJSISOVICS, E.v.: Die Cephalopodenfaunen der oberen Trias des Himalaya, nebst Bemerkungen über die Meere der Triasperiode.- Verh.k.-k.Geol.R.-A., 346-373, 1 Tab., Wien 1896.

MOJSISOVICS, E.v., WAAGEN, W. & DIENER, C.: Entwurf einer Gliederung der pelagischen Sedimente des Trias-Systems.- Sitzber.kais.Akad.Wiss. Wien, mathem.-naturw.Cl., 104, Abth. I, 1271-1302, 1 Tab., Wien 1895.

MOSTLER, H.: zur Mikrofauna des Unterkambriums in der Haziraformation - Hazara, Pakistan.- Ann.Naturhis.Mus. Wien, 83, 245-257, 1 Text-Fig., 1 Tab., 2 Pls., Wien 1980.

OFFIELD, T.W.: Preliminary Bibliography and Index of the Geology of Pakistan.- Records Geol.Surv. Pakistan, 12, 1, VI + 54 p., Karachi 1965.

OLDHAM, R.D.: A bibliography of Indian geology: beeing a list of books and papers, relating to the geology of British India and adjoining countries, published previous to the end of a.d. 1887.- XIII + 145 p., Calcutta (Government Printing) 1888.

PENCK, A.: Ziele der Erdkunde in Oesterreich.- Mitth.k.k.Geograph.Ges. Wien, 32, Anhang p. 1-16, Wien 1889.

REDLICH, K.A.: The Cambrian fauna of the eastern Salt Range.- Mem.Geol.Surv. India, Palaeont. Indica, New.Ser. 1, 1, 14 p., 1 Pl., Calcutta 1899.

SCHEIDEGGER, A.E.: On the Tectonics of the Western Himalaya.- Arch.Met.Geoph. Biokl., Ser.A, 28, 89-106, 14 Text-Figs., 1 Tab., Wien 1979.

SCHÖNLAUB, H.P.: Scenarios of Proterozoic and Paleozoic Catastrophes: A Review.- Abh.Geol.B.-A., 53, 59-75, 9 Text-Figs., 1 Tab., Wien 1996.

SCHOUPPE, A.v.: Die Mittel- bis Oberdevonische Korallenfauna von Kuragh (Chitral).- In: AMUOT, M. et al.: Fossils of the Karakorum and Chitral.- Italian Expedition to the Karakorum (K^2) and Hindu Kush. Leader Prof. A. DESIO, Scient.Rep. IV, Paläont.Zool.Botan., 1, 13-53, 6 Text-Figs., 3 Pls., Leiden 1965.

SENARCLENS DE GRANCY, R.: AV-Expeditionskartographie.- Mitt.Österr. Alpenverein, 46, 12-13, 3 Text-Figs., Innsbruck 1991.

SENARCLENS DE GRANCY, R. & KOSTKA, R. (Eds.): Grosser Pamir,- 400 p., Graz (Akadem. Druck- und Verlagsanstalt) 1978.

SIPÖCZ, L.: Kaliglimmer aus Ostindien.- Miner.Mitth., 31-32, Wien 1873.

STEININGER, F.F., SENES, J., KLEEMANN, K. & RÖGL, F. (Eds.): Neogene of the Mediterranean Tethys and Paratethys. Stratigraphic Correlation Tables and Sediment Distribution Maps.- Vol. 1: XIV + 189 p., Vol. 2: XXVI + 536 p., numerous Text-Figs. and Tabs., 10 coloured Maps, Vienna (University, Inst. of Paleontology) 1985

STOLICZKA, F.:Geological Sections across the Himalayan Mountains, from Wangtu-Bridge on the River Sutlej to Sungdo on the Indus: with an account of the formations in Spiti, accompanied by a revision of all known fossils from that district.- Mem.Geol.Surv. India, 5, 1-154, 10 Pls., Calcutta 1866 a.

STOLICZKA, F.: Summary of Geological Observations during a visit to the Provinces - Rupshu, Karnag, South Ladak, Zanskar, Suroo and Dras - of Western Tibet, 1865.- Mem.Geol.Surv. India, 5, 337-354, Calcutta 1866 b.

STOLICZKA, F.: Observations on fossil crabs from Tertiary deposits in Sind and Kutch.- Mem.Geol.Surv. India, Palaeont. Indica, Ser. 14, Vol. 1, Pt. 1, 16 p., 5 Pls., Calcutta 1871 a.

STOLICZKA, F.: Jura in Indien.- Verh.Geol.R.-A., p. 335, Wien 1871 b.

TIEFFENTHALER, J.:Des Pater Joseph Tieffenthaler d.G.J. und apostol. Mißionarius in Indien historisch-geographische Beschreibung von Hindustan. Aus Dessen lateinischen Handschrift übersetzt. Mit Anmerkungen und anderen Zusätzen, vorzüglich mit des Engl. Ingenieur-Major Herrn Rennel großen Charte von Hindustan, herausgegeben von Johann Bernoulli, etc.- Vol. 1: XXVI+370p., 39 Plates, Gotha (C.W. Ettinger) 1775. Vol. 2, Part 1: XVIII+210p., 10 Plates, 1788. Vol. 2, Part 2: XII+238p., 7 Plates, 1788. Vol. 3: 14+VIII+244p., 9 Maps, Berlin 1787.

TSCHERMAK, G.: Kalisalz aus Ostindien.- Miner.Mitth., 135-136, Wien 1873.

TSCHERMAK, G.: Steinsalz und Glauberit aus dem Pendschab.- Miner.Mitth., p.288, Wien 1873.

VOGELTANZ, R.: *Receptaculites neptuni* (Defrance) from Devonian of Owir An, Chitral, West Pakistan.- Records Geol.Surv. Pakistan, 19, II+1-4, 1 Text-Fig., 1 Tab., 2 Pls., Quetta 1969.

VOGELTANZ, R. & DIEMBERGER-SIRONI, M.A.: *Receptaculites neptuni* (Defrance) im Devon des Hindukush (Kurze Mitt.).- Anz.Österr.Akad.Wiss., mathem.-naturw. Kl., 100-101, Wien 1968.

WAAGEN, L.: Werfener Schichten in der Salt-Range.- Centralbl.Miner. etc., 285-288, Stuttgart 1900.

WAAGEN, W.: Abstract of results of examination of the ammonite-fauna of Kutch, with remarks on their distribution among the beds, and probable age.- Records Geol. Surv. India, 4, 89-101, 1 Tab., Calcutta 1871.

WAAGEN, W.: On the occurence of Ammonites, associated with Ceratites, and Goniatites in the Carboniferous deposits of Salt Range.- Mem.Geol.Surv. India, 9, 351-358, 1 Plate, Calcutta 1872 a.

WAAGEN, W.: Rough section showing the relations of the rocks near Muree (Mari), Punjab.- Records Geol.Surv. India, 5, 15-18, 1 Text-Fig., Calcutta 1872 b.

WAAGEN, W.: Jurassic Fauna of Kutch. The Cephalopoda (Ammonitidae).- Mem. Geol.Surv. India, Palaeont. Indica, Ser. IX, 4, 247 p., 60 Pls., Calcutta 1875.

WAAGEN, W.: Über einige strittige Punkte in der Geologie Indiens.- N.Jb.Miner., 559-562, Stuttgart 1879.

WAAGEN, W.: Section along the Indus from the Peshâwar valley to the Salt-Range.- Rec.Geol.Surv. India, 17, 3, 118-123, 1 Pl., Calcutta 1884.

WAAGEN, W.: Salt Range fossils from the Ceratite formation.- Mem.Geol.Surv. India, Palaeont. Indica, Ser. 13, 2 (1), 1-323, 40 Pls., Calcutta 1885 a.

WAAGEN, W.: Salt Range fossils of Products limestone group, Part 1-7.- Palaeont. Indica, Ser. 13, 1, 1-998, Calcutta 1885 b.

WAAGEN, W.: Note on some Palaeozoic Fossils recently collected by Dr. H. Warth in the Olive-group of the Salt-Range.- Rec.Geol.Surv. India, 19, I, 22-38, 1 Pl., Calcutta 1886.

WAAGEN, W.: Die carbone Eiszeit.- Jb.k.k.Geol.R.-A., 37, 143-192, 1 Text-Fig., 1 Tab., Wien 1887.

WAAGEN, W.: Salt Range Fossils. Vol. IV. Geological Results.- Mem.Geol.Surv. India, Palaeont. Indica, Ser. VIII, Vol. IV, Part 1+2, Text-Figs., Tabs., 4+8 Pls., Calcutta 1889-1891.

WAAGEN, W.: Note on the Bivalves of the Olive-group,Salt-Range.- Records Geol. Surv. India, 23, 38-41, Calcutta 1890.

WAAGEN, W.: Preliminary notice on the Triassic Deposits of the Salt Range.- Rec. Geol.Surv. India, 25, 182-186, Calcutta 1892.

WAAGEN, W.: Vorläufige Mitteilung über die Ablagerungen der Trias in der Salt-Range (Punjab).- Jb.k.k.Geol.R.-A., 42, 377-386, Wien 1893.

WAAGEN, W. & WENTZEL, J.: Salt Range fossils. Productus limestone fossils.- Mem.Geol.Surv. India, Palaeontologia Indica, Ser. XIII, I, 998 p., 128 Pls., Calcutta 1887.

WAAGEN, W. & WYNNE, A.B.: The geology of Mount Sirban in the Upper Punjâb.- Mem.Geol.Surv. India, 9, 331-350, 4 Text-Figs., 1 Map, Calcutta 1872.

WICHE, K.: Die Österreichische Karakorum-Expedition 1958.- Mitt.Geogr.Ges., 100, 280-294, 1 Text-Fig., 2 Pls., Wien 1958.

WICHE, K.: Le Periclaciaire dans le Karakorum de l'Ouest.- Biuletyn Peryglacjalny, No. 11, 103-110, 4 Photo-Plates, Lodz 1962.

ZUBER, R.: Beiträge zur Geologie des Punjab (Ostindien).- Jb.k.-k.Geol.R.-A., 64, 327-356, Wien 1914.

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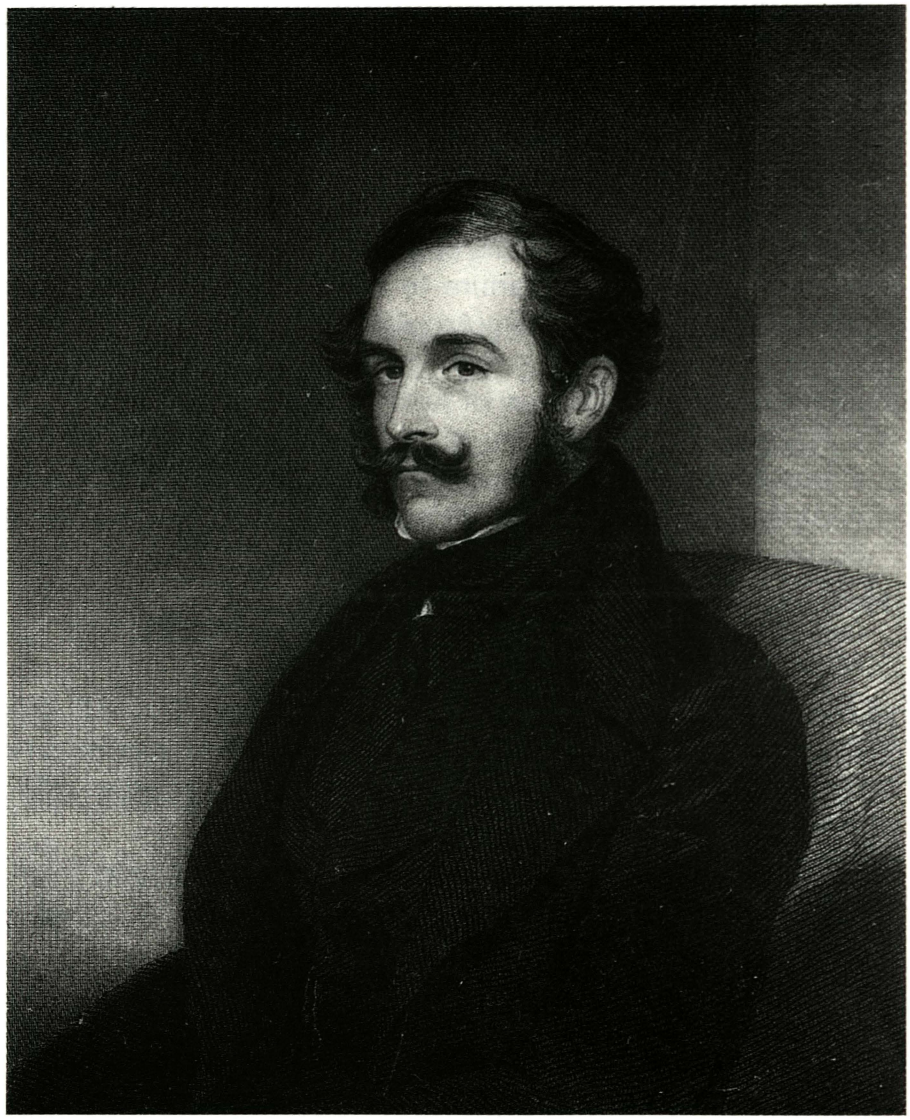
Text-Fig. 9: Letter-head of Austrian-German Hindukush Expedition 1970 (Courtesy of H. Gamerith).



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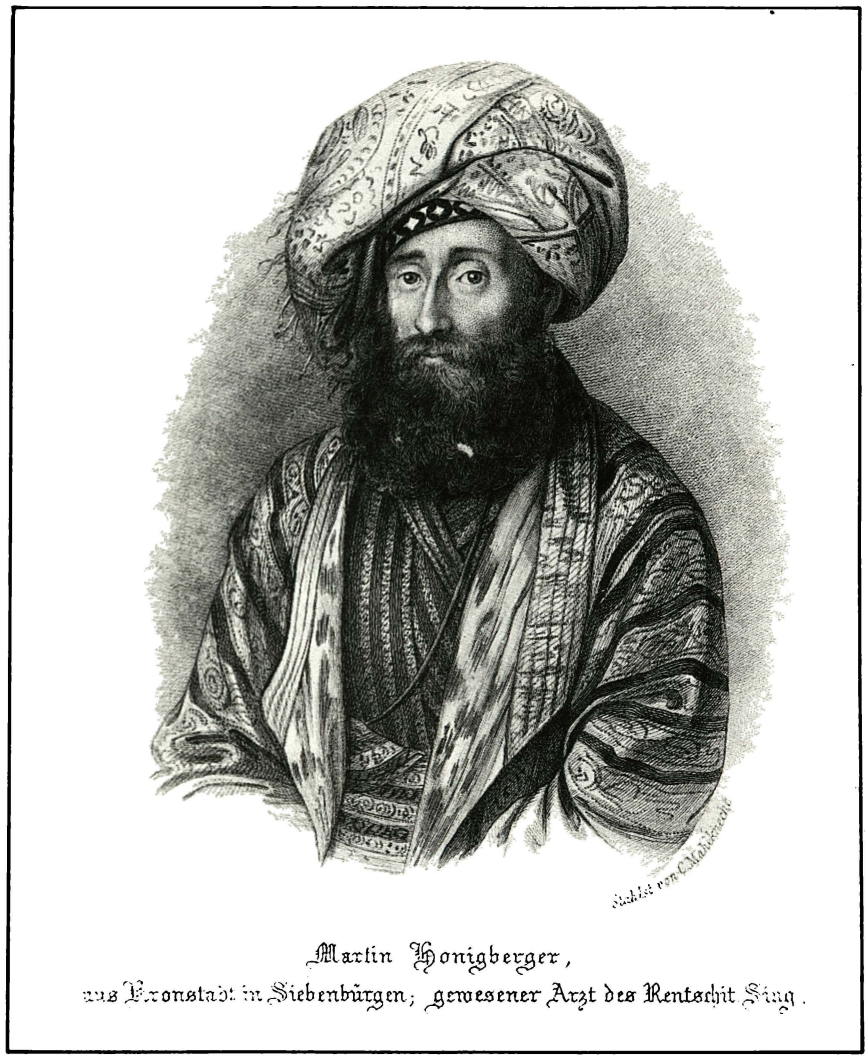

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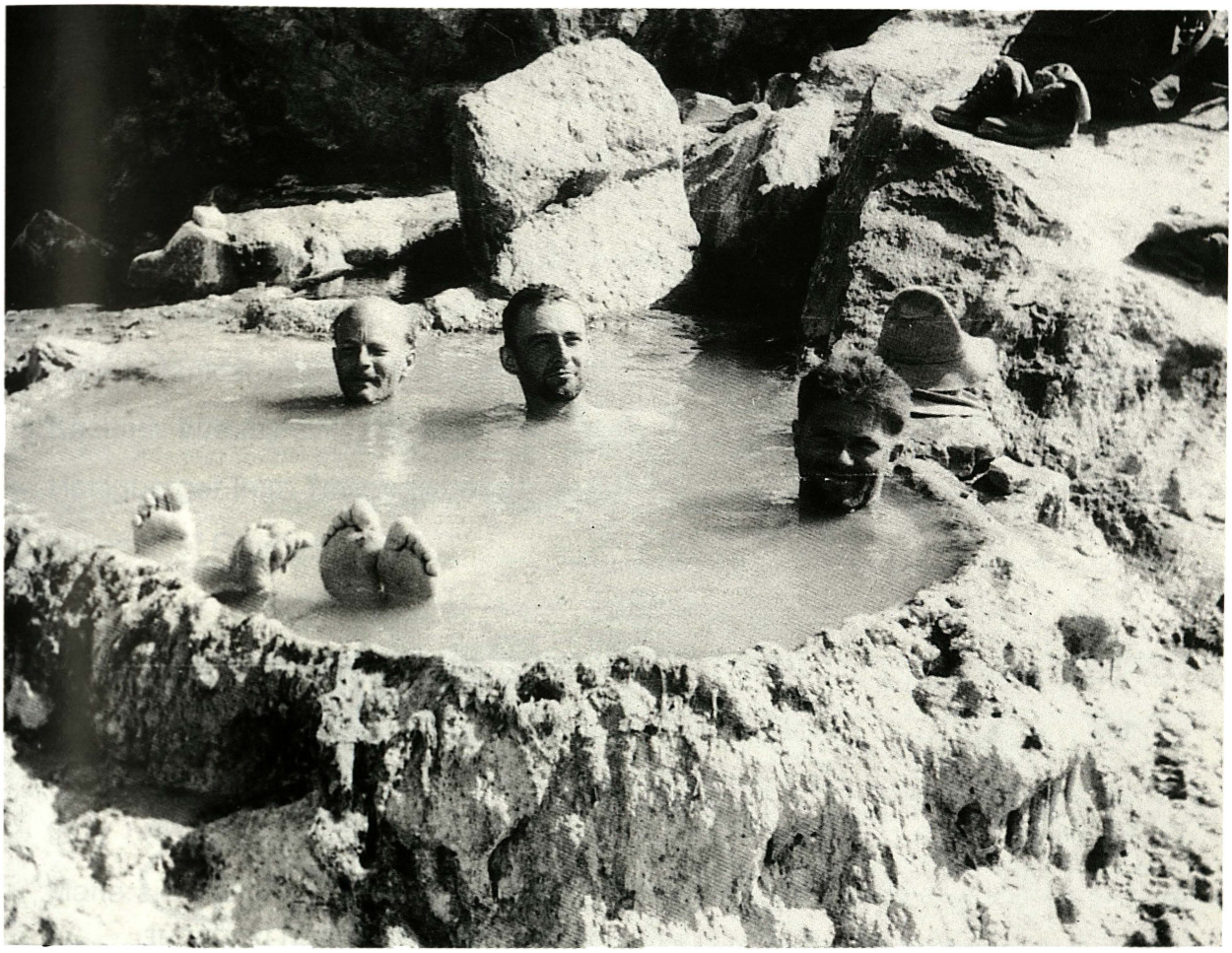

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