Geol. Bull. Univ. Peshawar, 1984, Vol. 17, pp. 87–100

COMPARISON OF TECTONIC AND METALLOGENIC PROVINCES OF AFGHANISTAN TO PAKISTAN

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ABSTRACT

Different ideas of tectonic and metallogenic zonation, and difficulties in communication between geologists working in Pakistan and Afghanistan over the last twenty years have limited exchange of information. Detailed work in Afghanistan shows 21 metallogenic zones with 37 associated ore districts. Also recorded are 1432 mineral-resource locations classified as : (1) large and medium deposits; (2) small deposits; (3) occurrences; (4) showings; as well as 306 broadly defined mechanical mineralogical haloes. This comprehensive resource analysis used the outmoded geosynclinal concepts of Russian work with metallogenesis, but is herein adjusted to a plate-tectonic framework and compared to the new tectonic zonation of Pakistan. Cross-border correlation of tectonic zones and metallogenic provinces could be useful in exploration strategy in Pakistan.

INTRODUCTION

Discovery of mineral resources is well known to require extensive exploration, coupled with detailed geologic mapping, sampling and assaying of deposits. Exploration strategy is sometimes left to random searches along paths of easiest access as in early days, but best mapping tactics today increasingly demand adherence to fundamental theories of ore and hydrocarbon genesis (Mitchell and Garson, 1981; Sawkins, 1984). Only in situations where commercial deposits are known already, or where exploration areas can be saturated with well trained resource geologists, are less sophisticated exploration strategies likely to be as beneficial. Use of coherent theories to explain ore genesis and probable location is also advantageous to exploration geologists in need of support from financial and government officials. Adaptation of metallogenic zonation of Pakistan to a plate-tectonic framework is well underway (Sillitoe, 1978, 1979; Bilgrami, 1980) and can be extended across neighbouring national boundaries where sufficient data exist for comparison. Resource investigation in Pakistan is proceeding well, given inherent difficulties with terrain, logistics, and access to the newest or more expensive exploration techniques, but can be improved with correlative information from nearby countries. Newly available intensive resource assessments from Afghanistan offer this potential best.

AFGHANISTAN RESOURCES

The last twenty years of geologic mapping of Afghanistan have resulted in coverage of the entire country at 1:250,000 scale, with compilation at 1:500,000 and publication at 1:2,000,000 and smaller scales. Especially promising resource zones received more detailed mapping at larger scales. Afghan geologists were involved in this work from the first, of course, but overall direction and staffing of the intensive exploration was Russian. Subsidiary general mapping efforts were done by Germans, French and others. In the 1970s assessment of the resource situation in Afghanistan became involved in geopolitics and geologic reports were regarded as low-level state secrets (Shroder, 1983). Nevertheless, the printing (but only limited release) of economic analyses and inventories of mineral resources (Kavalsky and others, 1978; Neilson and Gannon, 1976; Shareq and others, 1977) showed good potential for development of known resources and further discovery of important new deposits.

The most important inventory of minerals began with a 48-page discussion of the chief geologic features, including stratigraphy, tectonics, and igneous complexes (Shareq and others, 1977). This served as background to general discussions of metallogeny, and was followed by a massive compendium of 1432 specific mineral-resource locations, described and classified into four: (1) large and medium, and small deposits (table 1); (2) occurrences (table 1); and (3) showings; in addition, there were 306 broadly defined areas where occur (4) mechanical mineralogical haloes suggesting potential occurrences of specific minerals. The ground-water aquifers were extensively described, including 198 specific spring localities, of which 112 are mineralized and 86 are fresh water occurring in desert regions. Eleven high-quality maps were included in the report :

(1) Geologic map (1:2,500,000).
(2) Tectonic map (1:2,500,000).
(3) Magmatic complexes (1:2,000,000).
(4) Mineral deposits, occurrences, and showings (1:2,000,000).
 a. Fuel minerals and ferrous metals.
 b. Nonferrous metals.
 c. Tungsten and tin.
 d. Rare and precious metals.
 e. Nonmetallic minerals.
 f. Hydrogeology.
 g. Fresh and mineral waters.
(5) Metallogenetic zones (1:5,000,000).

TABLE 1. PARTIAL LIST OF MOST IMPORTANT MINERAL RESOURCES OF AFGHANISTAN (adapted from Shareq and others, 1977; further important finds of hydrocarbons and uranium are known to have been discovered since 1977, but are not included here).

MINERAL DEPOSIT TYPE	DEPOSIT SIZE Large and Medium	Small	Occurrences
Oil	—	2	—
Gas	2	3	—
Coal	—	9	36
Lignite	—	—	3
Chromium	—	1	8
Iron	1	4	52
Manganese	—	—	1
Aluminum	—	1	6
Bismuth	—	—	9
Cadmium	—	1	—
Copper	1	5	143
Lead & Zinc	—	5	61
Mercury	—	—	28
Molybdenum	—	—	2
Tin	—	3	44
Tungsten	—	—	24
Beryllium	—	4	11
Cesium & Rubidium	—	3	3
Lithium	2	8	21
Tantalum & Niobium	—	5	13
Rare Earths, Thorium & Uranium	—	1?	4
Gold	2	4	54
Silver	—	—	4
Barite	1	1	11
Celestite	1	2	—
Fluorite	1	—	4
Sulfur	—	1	4
Apatite	—	—	1
Phosphorite	—	—	1
Asbestos	—	2	17
Graphite	—	—	6
Gypsum	—	—	17
Muscovite	2	—	19
Talc & Magnesite	—	3	4
Emerald	—	—	7
Garnet	—	—	1
Kunzite	—	1	—
Lazurite	1	—	—
Ruby	—	1	—
Serpentine	—	—	4
Tourmaline	—	—	3
Optical Calcite	—	—	5
Electronic Quartz	—	1	9

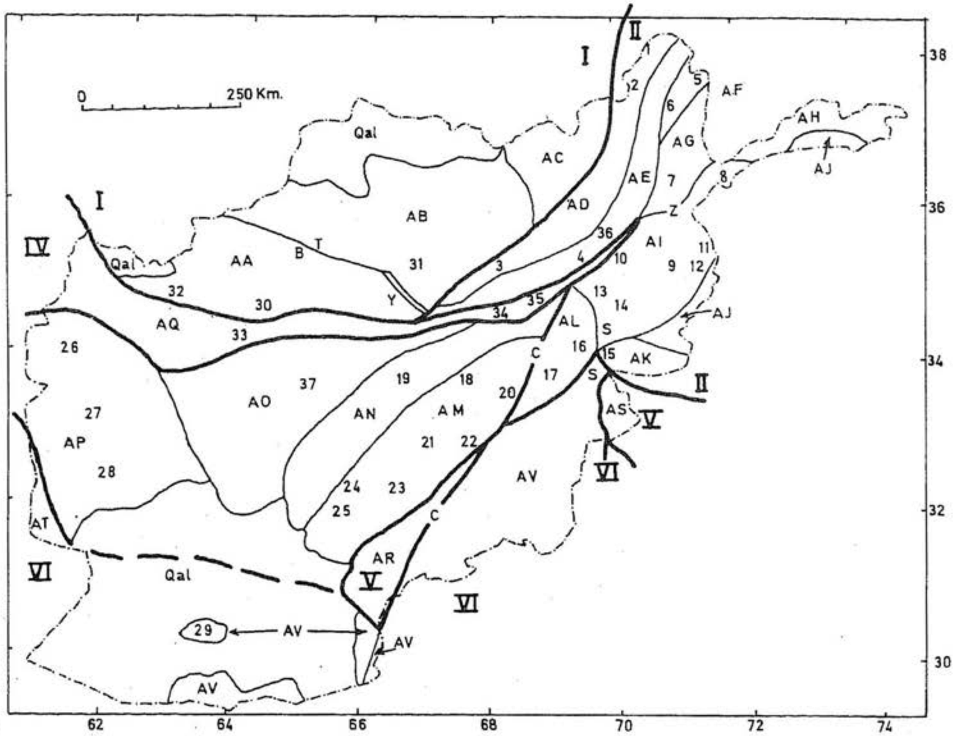

Figure 1. Metallogenic zones in Afghanistan that are keyed by letters and Roman numerals to table 3 and by numbered ore districts to table 2. Data were adapted from Shareq and others (1977) and Shroder (1983). BT — Band-e-Turkestan fault; Y — Yakawlang graben; Qal — Quaternary alluvium.

METALLOGENIC ZONES OF AFGHANISTAN

Twenty-one metallogenic zones were delineated (Shareq and others, 1977), largely on the basis of boundary faults, although tectonic style and age, rock age, and sediment cover were also used. Eighty-five characteristic minerals or elements were listed in total for the zones, and 37 ore districts were separately specified and divided into major and minor mineralization zones. Russian geologists tend to follow ideas relating metallogenesis to geosynclinal tectonic settings (Bilibin, 1948, 1955, 1968; Smirnov, 1977), with the result that many interpretive difficulties arise because of imperfections in the outmoded geosynclinal hypothesis. Nevertheless, it is possible to adapt without major reinterpretation the original metallogenic zonation to the plate-tectonic paradigm by separating only a few of the disparate elements (table 3). In a few cases herein the original structural blocks of the Russian mapping were not split into separate parts; for example, some thin ophiolitic zones were retained as part of the Iran-Afghanistan microcontinental plate fragments and not separated into individual obduction zones. Adherence to the original scheme as much as possible reduced possibility for misinterpretation of a few areas not personally visited. Six fundamental metallogenic zones are herein recognized in Afghanistan: (1) Eurasian pre-collisional margin — platform and basin zone; (2) Collisional zone; (3) Iran-Afghanistan micro-continental plate; (4) Geosuture structures; (5) Obduction zones; and (6) Convergence boundary — subduction zone (Fig. 1).

Eurasian margin. The pre-collisional margin of the Eurasian plate in Afghanistan was originally mapped as the "Turan epi-Hercynian platform of north Afghanistan" (Shareq and others, 1977). It is a passive margin, miogeosynclinal area of carbonates and clastics of Cretaceous and Paleogene age, and has been mildly warped, except along a few more intensely deformed W–NW trending fault and fold systems. The Band-e-Turkestan fault that separates the Murghab and Balk blocks of the platform is a dextral strike-slip system with an abrupt flexure. Probable locking of the large Hari Rod fault zone to the south in late Cenozoic has caused active movement along the Band-e-Turkestan fault and consequent opening of the Yakawlang graben at the flexure. Superimposed over the east end of the platform and close to the active tectonism of Badakhshan occurs the fore-Badakhshan molasse trough of Neogene age. The trough corresponds to the "hinterland basin" type of mineralization zone (Mitchell and Garson, 1881, p. 295–296). This area of clastic deposition from the rising Hindu Kush-Pamir collisional zone is being actively deformed by N–S trending folds that are affecting the courses of the Kokcha, Kunduz, and Amu rivers across these folds.

Resource zones of most interest in this area include: (1) oil and gas in stratigraphic and structural traps in the western part of the Balk block; (2) extensive coal deposits, typical of passive continental margins (Mitchell and Garson, 1981, p. 92); (3) placer gold in the Neogene clastics eroded from the adjacent uplifted collisional zone and deposited in the fore-Badakhshan trough. There are also indications of further oil and gas throughout the border area of northern Afghanistan because of its geology similar to the areas of known production directly over the border in U.S.S.R. (Petrov, 1972, p. 363–365). In addition, a SW–NE trending zone of salt intrusions has uparched platform sediments in the east Balk block and fore-Badakhshan trough to provide structural potential for further hydrocarbon entrapment. Some mineralization is associated with intrusive and extrusive igneous rocks and early Mesozoic sedimentary rock overlain by the platform rocks. Thus the Balkab and Okhankashan ore districts (table 2) occur where rivers have cut down through overlying platform sedimentary rocks to expose the deeper rocks.

Collisional zone. The nine major parts of the collisional zone constitute the heart of the Hindu Kush-Afghan Pamir mountains, and include a wide range of complexly deformed crystalline and sedimentary rocks of Archean through Phanerozoic age. This zone was originally mapped as "median masses of Baikal consolidation, areas of Hercynian folding, and goesuture structures with Paleozoic and Mesozoic superimposed troughs" (Shareq and others, 1977). Much of the

TABLE 2. AFGHANISTAN ORE DISTRICTS (from Shareq and others 1977).

MAP NUMBER (1)	ORE DISTRICT	MINERALIZATION MAJOR	MINOR
1	Nesay	Cu	—
2	Chilkonshar	Au	Cu, Pb, Zn
3	Doshi	Cu, Pb, Zn	F, Au
4	Bazorak	Muscovite	—
5	Pajdarra	W, Au, Cu	—
6	Furmorah	Fe, Au	—
7	Sari-Sang	Lapis lazuli	--
8	Iskashim	Li, Ta, Sn	—
9	Nurestan	Muscovite	Semi-precious stones
10	Rawat	Emerald, Be	—
11	Dewaz	Li, Ta, Be, Sn	Semi-precious stones
12	Marid	Li, Ta, Sn	—
13	Pachaghan	Muscovite	—
14	Laghman	Be, Li, Cs, Ta, Sn	Semi-precious stones
15	Sarobi	Ruby, Muscovite	—
16	Kabul	Cu	—
17	Loghar	Cr	Se, Ti
18	Besud	Sn, W	Cu, Pb, Fe
19	Shakhrestan	Li, Ta, W, Sn	Cu, Pb, Au
20	Wardak	W, Bi, Mo	—
21	Oruzghan	W, Sn, Bi	Cu, Pb, Zn, Fe
22	Moqur	Au, Sn	Cu, Pb, Zn
23	Kundalyan	Cu, Au	Pb, Zn, Mo
24	Bakhud	F	Ag, Pb, Zn
25	Chinar	Sn, Pb, Zn, Fe	Cu, W, Cd
26	Nazarkhan	Cu, Pb, Zn	Sn, Hg, Au
27	Shindand	Sn, Cu	Pb, Zn, Au, W, Mo
28	Farah	W, Cu	Sn, Pb, Zn, Ba
29	Khanneshin	U, Rare earths, P	—
30	Okhankashan	Cu, Au	Fe, Zn, Mo
31	Balkab	Cu, Zn	—
32	Safed Koh	Ba, Pb, Zn, Cu	Hg, Au
33	Siah Koh	Pb, Zn	Cu, Ba, Fe
34	Haji-Gak	Fe	—
35	Farenjal	Ba, Pb, Zn	Mn, Hg, Au
36	Panjsher	Fe	Pb, Zn, Ag
37	Farahrod	Hg	Cu, W

(1) Keyed by number to figure 1.

TABLE 3. METALLOGENIC ZONES IN AFGHANISTAN, arranged herein according to plate-tectonic theory after data by Shareq and others (1977). Roman numerals and letters are keyed to figure 1.

I. Pre-Collisional Eurasian Plate Margin — Platform and Basin Zones ("Turan Epi-Hercynian Platform").

AA Murghab block (copper, gold, iron, molybdenum).

AB Balk block (copper, zinc, mercury, strontium).

AC Fore-Badakhshan molasse (gold).

II. Interplate Marginal Collisional Zone ("Hercynian folded region, northeast part ot median mass of Baikal consolidation, part of Alpine folded region").

AD Surkhab-Jaway block complex (copper, gold, lead, zinc).

AE Western Badakhshan block complex (tin, lithium, tantalum, niobium, beryllium).

AF Shewa-Nakhchirpar block complex (iron, copper, tungsten, gold).

AG Eastern Badakhshan Archean block complex (lazurite, lithium, tantalum, tin).

AH Wakhan block (tin, iron, copper).

AI Nurestan block (lithium, beryllium, tantalum, niobium, cesium, tin, tungsten, muscovite, precious stones).

AJ Konar block (copper, iron).

AK Spin-Ghar block (talc, magnesite).

AL Kabul block syntaxis (copper, chromium, iron).

III. Iran-Afghanistan Micro-Continental Plate ("Central Afghan mass of Baikal consolidation").

AM Arghandab-Tirin block (tin, tungsten, fluorite, copper, lead, zinc, gold, iron).

AN Helmand block (lithium, tantalum, tungsten, tin, copper, lead).

AO Harutrod block (mercury).

AP Shindand-Kishmaran block (tin, tungsten, copper, lead, zinc).

IV. Interplate Marginal Geosuture Structures (with Paleozoic–Mesozoic superimposed troughs).

AQ Hari Rod-Panjsher fault system (iron, lead, zinc, barite, gold, mercury).
Interplate Marginal Geosuture Structure (transform and thrust boundaries).

C Chaman-Moqur-Kabul fault system.

Z Zebak fault system.

S Sarobi fault system.

V. Interplate Marginal Obduction Zones ("area of Alpine folding").

AR Tarnak block (mercury, chromium).

AS Khost block (chromium, asbestos).

VI. Interplate Marginal Convergence Boundary ("area of Alpine folding").

AT Asparan block (lead, zinc, mercury).

AU Chagai volcanic arc and magmatic belt ("Ragistan") (uranium, rare earths, phosphorous, copper, tin).

AV Katawaz flysch basin (lead, zinc, mercury).

collisional zone is transacted by SW–NE trending faults, several of which have major strike-slip components of movement that bend eastward into thrusts. A complex warped or doubly dipping remnant subduction zone occurs beneath the central Hindu Kush, and is thought to be responsible for the high frequency/high magnitude seismicity at intermediate focal depths there.

In the collisional zone exist extensive areas with minerals emplaced prior to collision, which reinforces Sillitoe's conclusion (1979, p. 178) that pre-Mesozoic ore types might hold best potential in the Himalaya. Of possible importance to future mineral exploration, however, are certain trends that begin in the Hindu Kush and pass into northern Pakistan. The Konar and Nurestan blocks, for example, are characterized by Archean crystallines, Paleozoic-Mesozoic clastics and spilite–keratophyric rocks, Proterozoic and Triassic granitoids, and extensive granites of Oligocene age. Several zones of beryllium, lithium, cesium, tantalum, and tin ore (table 2) are associated with these areas and may extend along strike into the Chitral and Gilgit areas. In addition, the rubies in the Sarobi area of Afghanistan, on the Russian side of the Ab-i-Panj valley opposite Badakshan and Wakhan, and in Hunza are all located in the hinterland margin of the overriding Eurasian plate (Mitchell and Garson, 1981, p. 267–268) and indicate potential for further discoveries in northern Pakistan.

Micro-continental plate. The Iran-Afghanistan micro-continental plate consists of several accreted terranes that moved from Gondwanaland to impact with the Eurasian plate prior to the culminating collision of the Indo-Pakistan plate. Obducted ophiolitic sequences occur between several of the fragments, but only the large Tarnak block ophiolite zone was assigned herein to the obduction-zone category of metallogenic zones (table 3). The plate fragments were originally mapped by Shareq and others (1977) as "median masses of Baikal consolidation". As a whole this extensively faulted micro-continental plate seems now to be moving southwest between the right-lateral Hari Rod and Band-e-Turkestan faults on the north, and the left-lateral Chaman-Moqur-Kabul fault system on the southeast; a result of the continued impingement of the Eurasian and Indo-Pakistan plates on either side.

Diverse rock types occur in this area; mainly late Paleozoic and Mesozoic clastics and carbonates, with extensive Oligocene granite batholiths in the Argandab-Tirin zone. Mineralization is variable (tables 2 & 3), reflecting a complex history. Some of the ore emplacement, especially that of tin on the west and southeast rims (Shindand-Kishmaran and Argandab blocks) may reflect back-arc magmatism (Mitchell and Garson, 1981, p. 218–222).

Geosuture structures. The Hari Rod-Panjsher geosuture is such a prominent and wide zone of sheared and folded rocks with superimposed Phanerozoic depositional troughs across it that it was classified separately as a metallogenic province by Shareq and others (1977), while also recognizing that it included both Hercynian and Alpine orogenesis. This site of long-continued orogenic activity is a reflection of the micro-continental plate collisions, followed by the main Indo-Pakistan plate collision. Several ore districts occur along it (table 2); some north of Kabul having been mined for centuries. Several other prominent geosuture structures also occur in Afghanistan (table 3), but are not generally wide enough to classify as separate metallogenic zones although mineralization may occur along these zones.

Obduction zones. The Tarnak and Khost blocks of "Alpine folding" (Shareq and others, 1977) are two zones of ophiolite suites and other rocks. The Tarnak block consists mainly of Cretaceous to Paleogene igneous rocks, whereas the Khost block has late Paleozoic to Eocene clastics, carbonates and igneous rocks. The main mineralization is chromium, asbestos, and mercury (tables 2 & 3). The Khost block on the Pakistan border is paralleled by similar rocks in Kurram and north Waziristan where chromium mineralization also occurs. The asbestos in Khost is not of high quality and may therefore not be significant to exploration in adjacent Pakistan. On the other hand, asbestos mineralization is newly recognized (Hamidullah, pers. comm., 1984) in the North West Frontier Province so the cross-border relationships could be further analyzed.

Convergence boundary. The southwest and south edges of Afghanistan (zone of Alpine folding; Shareq and others, 1977) are marked by a variety of features associated with volcanism above a subduction zone, and flysch deposition between the Indo-Pakistan plate and the sutured Iran-Afghanistan microplate/Eurasian plate (table 3). Large parts of the Chagai and Asparan blocks are now covered with late Cenozoic sediments that obscure the underlying geology of the calc-alkaline volcanic and intrusive centers there. Koh-i-Khanneshin volcano, which deflected the course of the lower Helmand river, is a uranium-thorium ore district (table 2). The Katawaz belt is mainly volcano-flyschoid sediments with numerous folds. Schreiber and others (1972) judged this area to have reasonable petroleum potential, but political manipulations forced out a French drilling team in 1977 (Shroder, 1983, p. 124 & 137).

CORRELATION OF TECTONIC AND METALLOGENIC ZONES BETWEEN AFGHANISTAN AND PAKISTAN

Tectonic zonation of Pakistan is largely complete (Kazmi and Rana, 1982) (table 4), but to date no metallogenic map based on plate tectonics of Pakistan has been published, although an early attempt using geosynclinal theory was made (Shcheglov, 1969). At present, however, a new metallogenic map based on plate tectonic theory is in draft status by the Geological Survey of Pakistan. The paper herein is an attempt to assist that project by providing collateral information from Afghanistan, some of which previously has not been available freely. Considered collectively, the tectonic and metallogenic regimes of the two countries can be dovetailed together neatly along the political border to delineate a swath 12000km broad across the jumbled mosaic of tectonic fragments between the Eurasian and Indo-Pakistan plates (Fig. 2). In only a few places do the

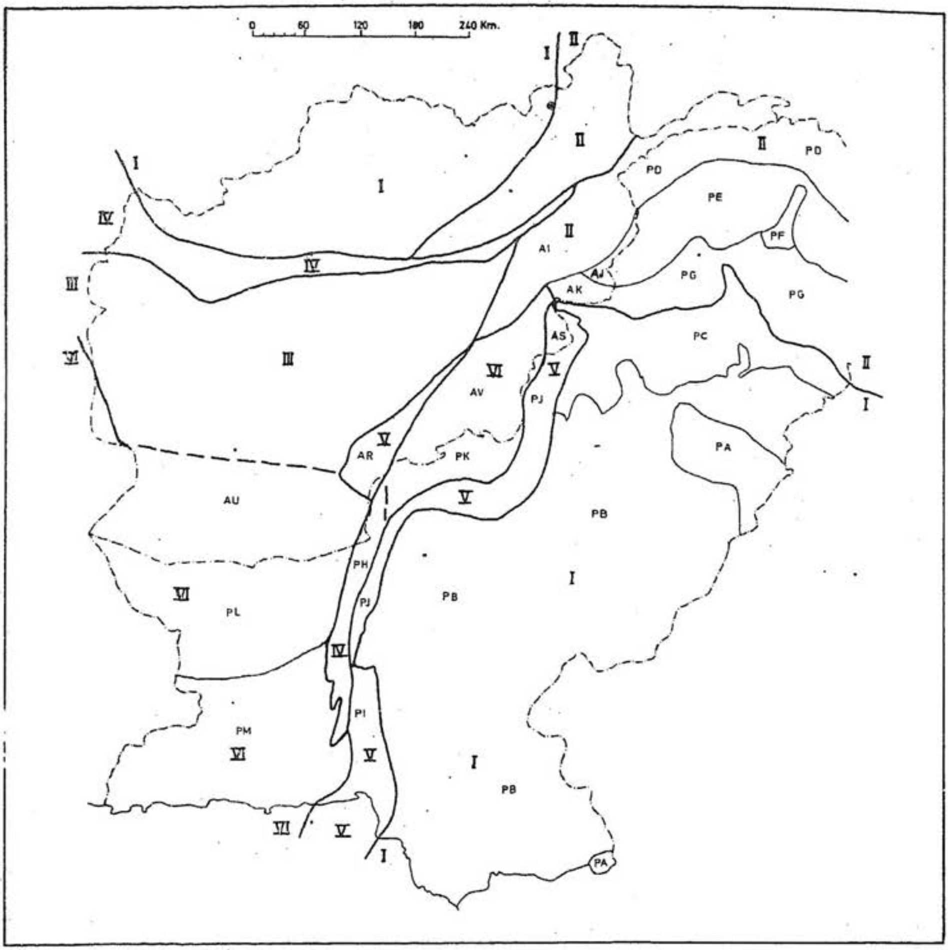

Figure 2. Zonation of Afghanistan and Pakistan according to a plate-tectonic framework to assist analysis of metallogeny. Map is adapted from Shareq and others (1977) and Kazmi and Rana (1982). I — Pre-collisional plate margins; II — Interplate marginal collisional zones; III — Iran-Afghanistan micro-continental plate; IV — Interplate marginal geosuture structures; V — Interplate marginal obduction zones; VI — Interplate marginal convergence boundary Letters of zones in Afghanistan are keyed to table 3 and figure 1; zones in Pakistan to table 4.

cross-border correlations need reinterpretation to enhance fit. For example, the basic rocks of the Konar block in Afghanistan (Fig. 1) are more extensive than the connecting Kohistan belt shown by Kazmi and Rana (1982). This suggests that the extreme western part of the Kohistan rocks in Pakistan should be remapped and reinterpreted. On the other hand, the rocks mapped on the basis of limited field work as Konar type in southern Wakhan by Shareq and others

(1977) (Fig. 1 herein) are actually part of the Karakorum belt of Pakistan, and were mapped that way in figure 2. In addition, a small part of the Himalayan fold belt extends only a few kilometers past Parachinar into Afghanistan (Kazmi and Rana, 1982) and therefore was not included in figures 1 or 2. Along the remainder of the border between the two countries, the geological mapping was exceptionally similar, thus facilitating correlation.

Thus from the Karakorum and Wakhan in the northeast to the Chagai hills spanning the border in the southwest, the cross-border correlations of metallogenic (table 3) and tectonic zones (table 4) are as follows (Pakistan zone — Afghanistan zone) :

(PD) Karakorum (Tethyan) fold belt — (AI) Nurestan block.

(PE) Kohistan volcanic and calc-alkaline magmatic belt — (AJ) Konar block.

(PG) Himalayan crystalline schuppen zone — (AK) Spin Ghar block.

(PJ) Balla Dhor-Zhob-Kurram ophiolite belt and schuppen zone — (AS) Khost block.

(PK) Karakhorasan flysch basin — (AV) Katawaz flysch basin.

(PH) Chaman-Nal Ornach fault system — Chaman-Moqur-Kabul fault system.

(PL) Chagai volcanic arc and calc-alkaline magmatic belt — (AU) Chagai volcanic arc and magmatic belt.

TABLE 4. TECTONIC ZONES IN PAKISTAN, arranged from Kazmi and Rana (1982). Zonation here emphasizes border areas contiguous with Afghanistan.

I. Pre-Collisional Indo-Pakistan Plate Margin — Platform and Basin Zones.
- PA Shield block.
- PB Foreland belt of monoclinal zones, platform slopes, downwarp and upwarp zones, and foredeeps.
- PC Folded foredeeps and pericratonic shelf areas.

II. Interplate Marginal Collision Zone.
- PD Karakorum (Tethyan) fold belt.
- PE Kohistan volcanic and calc-alkaline magmatic belt.
- PF Nanga Parbat–Haramosh massif.
- PG Himalayan crystalline schuppen zone.

III. Interplate Marginal Geosuture Structures.
- PH Chaman-Nal Ornach fault system (with flysch).

IV. Interplate Marginal Obduction Zone.
- PI Bela ophiolite belt.
- PJ Balla Dhor-Zhob-Kurram ophiolite belt and schuppen zone.

V. Interplate Marginal Convergence Boundary.
- PK Karakhorasan flysch basin.
- PL Chagai volcanic arc and calc-alkaline magmatic belt.
- PM Makran flysch basin.

Within this swath between the two plates are rocks and mineral deposits resulting from several different tectonic styles and mineral genesis modes. Tectonic styles include in both countries passive plate margins, submarine trenches, magmatic arcs, possible back-arc magmatic belts and thrust belts, remnant ocean basins, suture zones and collision-related ophiolite sheets, hinterland margins of the overiding plate, foreland thrust belts, foreland basins, hinterland basins, intermontane troughs and graben of the foreland and hinterland, and transform fault extensions into continental margins (Mitchell and Garson, 1981). Specific mineral genesis types for Afghanistan and Pakistan have not been adequately described as yet, but in general are the same as those listed for Pakistan (Ahmed and Abid, 1983). These include types that are ophiolitic, metamorphic/hydrothermal, pegmatitic, porphyritic, contact metasomatic, pyrometasomatic, replacement, volcanogenic, sedimentary, Kruko-type, Manto-type, ground-water sedimentary, Mississippi valley-type, sandstone-type uranium, and transform-fault related.

Sillitoe (1978, 1979) considered these wide varieties of tectonic styles and mineral-genesis types for southern and western Pakistan and for the northern mountains. He was optimistic for further discovery of ore in the south and west because of the complex juxtaposition of passive margin, miogeosynclinal platform facies, ophiolitic and intrusive-extrusive calc-alkaline magmatism related to subduction, transform-fault-related mineralization, and sedimentary mineralization. On the other hand, he also thought that base- and precious-metal ores, including epithermal precious-metal, contact metasomatic, and porphyritic copper deposits would be unlikely to be found associated with the anatectic granites of the Karakorum Himalaya. In addition, deposits resulting from metamorphic mineralization are typically small and unlikely to support other than small-scale mining operations.

From the optimistic point of view of this paper, however, the best indicators of potential for future discoveries are the comparisons such as between the Nurestan block of Afghanistan and the Karakorum (Tethyan) fold belt of Pakistan. For example, the many pegmatites with rare earths and tin could also occur in Pakistan, and more gemstone deposits are likely, as in Afghanistan (Rossovskiy, 1980). Other more detailed comparisons may prove useful as well, especially in the older rocks.

Sillitoe (1979, p. 178) recognized that pre-Mesozoic ore types could well hold the best potential in the Himalaya. Plate-tectonic reconstructions of late Precambrian and Paleozoic environments might therefore help in recognition of metallogenic environments that were subsequently subjected to Himalayan orogenesis. This idea is particularly relevant in Afghanistan where so much of the central collision zone involves Precambrian and Paleozoic crustal fragments, some with important mineral deposits. Examples of known mineral deposits from these areas include: (1) the presently mined Ainak copper in the Kabul syntaxis; (2) the Haji-gak iron at the edge of the Hari Rod-Panjsher geosuture but within the Iran-Afghanistan micro-continental plate; and (3) the well known Sari-Sang lapis lazuli mines in the Archean block complex of the Badakhshan collisional zone. Similarly in Pakistan, some of the pre-Mesozoic crustal fragments may hold promise, although their sedimentary cover or difficult terrain restricts easy exploration.

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