DEPARTMENT OF THE INTERIOR

U.S. Geological Survey

The Undiscovered Oil and Gas of Afghanistan

by

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ABSTRACT

Afghanistan is made up largely of a series of continental fragments which moving northwards, docked and accreted to the southern proto-Asia continent. The tectonization of the accreted terranes is generally severe and petroleum prospects are limited essentially to the 48,000 mi^2 (124,000 km^2) North Afghanistan basin. This basin is the Afghan portion of the Turanian platform, plus the orogenic belt around its southern and eastern perimeter. Exploration to date is judged immature. Some 5 trillion cubic feet (tcf) of gas and 80 million barrels of oil were discovered by 1980. There are two types of traps: Mesozoic low-amplitude drapes or tilted fault blocks, and Neogene high-amplitude folds. Appreciable reservoirs are limited to three horizons, Upper Jurassic, Lower Cretaceous, and Paleogene of which the Lower Cretaceous are the best. Source rock is confined largely to the Lower and Middle Jurassic shales. Upper Jurassic evaporites are a barrier between the Jurassic source shales and the Lower Cretaceous reservoirs and Tertiary folds. There appear to be five principal plays. The estimated total recoverable petroleum in these plays is 300 million barrels of oil, 9.6 tcf of gas, and 145 million barrels of condensate.

INTRODUCTION

Afghanistan, with an area of some 250,000 mi^2 (647,500 km^2), lies athwart the Alpine-Himalayan orogenic belt. On the north is the platform area of Soviet central Asia, to the south and east is the Indian sub-continent, and to the west are the Zagros-Eburz mountains of Iran.

The undiscovered oil and gas appear to be limited essentially to northern Afghanistan. This area has been under the sphere of Soviet influence since the 1960's, and the little available recent geologic literature is largely in Russian.

This assessment will follow the general methods I have used in evaluating the undiscovered oil and gas resources of the adjoining southern Asia, i.e., Pakistan, India, Bangladesh, and Burma (Kingston, 1986). The focus of this study is directly on the significant geologic factors concerning petroleum occurrence. The study is structured to support what is essentially a play-analysis approach to the assessment of undiscovered petroleum resources. Since a quantitative assessment is required, every appropriate estimate of a pertinent geologic or historical factor is quantified numerically, even though it may be only an informed guess. Later information may cause a revision of the number, which then can be introduced into the system, effecting a corresponding change in the overall resource estimate.

The play-analysis method used here is a modified volumetric yield method with each of the appropriate geologic factors considered separately (Roadifer, 1975). The analysis is built up of seven principal estimates, i.e., acres of untested trap area, percent of untested trap area which is presumed to be productive, feet of average effective pay, percent of oil (versus gas), primary oil recovery in barrels per acre-foot (BBLS/AF) (a function of reservoir characteristics), gas recovery in thousands of cubic feet per acre foot (MCF/AF), and natural gas liquids (NGL) recovery in barrels per million cubic feet of gas (BBLS/MMCF). The estimates are made in ranges of values to indicate varying degrees of certainty. These ranges are summarized in play-analysis sheets, tables 2-6. For brevity, only the most likely case, or mode, of each range is used in the text discussion of the rationale for the various estimates.

REGIONAL GEOLOGY

The geology of Afghanistan is structurally complicated, substantially limiting the area favorable to the generation and accumulation of petroleum. The country is made up essentially of a succession of narrow northeast-trending terranes. The terranes, consisting of at least three narrow continental fragments from Paleozoic to Tertiary in age, have moved northward colliding obliquely with the rigid Asian continental mass (the epi-Hercynian consolidated Turanian platform of southern USSR and northern Afghanistan). The last arriving fragment was the relatively much larger India continental block, which smashed northward obliquely into the earlier arrived blocks imparting much additional folding and faulting (Alpine orogeny). This last collision caused large wrench faults to form and changed the structural trend accommodating the oblique direction of impact. The accreted blocks are separated by what appear to be sutures along which ophiolites are present, apparently the only remnants of subducted oceanic crust representing oceanic spaces of unknown width.

Within Afghanistan are three principal areas of thick sedimentary rocks: (1) the North Afghanistan basin, adjoining the northern boundary, (2) the large area of southwestern Afghanistan drained by the Helmend River, and (3) the Katawaz area between the Chaman wrench fault and the eastern border (fig. 1).

The second area, southwestern Afghanistan, has a thick sedimentary cover as indicated by aeromagnetic survey, but the sediments are probably largely melange as are those immediately to the south in the Baluchistan province of Pakistan; furthermore, where cropping out, the Neogene sediments are highly folded and faulted. The prospects for petroleum would be negligible and are not considered further.

The third area, the Katawaz area, has sediments up to 10,000 ft thick ranging in age from Permian to Oligocene but here again the rocks are severely folded and faulted. In the northern part of this area, the rocks are largely metamorphosed, and farther south they are less metamorphosed but severely folded. The petroleum prospects are considered negligible.

Only the first area, the North Afghanistan basin (fig. 1), has appreciable prospects for petroleum. It is in part the southeastern extremity of the rigid Turanian platform, which extends up into central Asia, and in part the faulted and folded orogenic zone around the south and east sides of the Turanian platform (figs. 1 and 2).

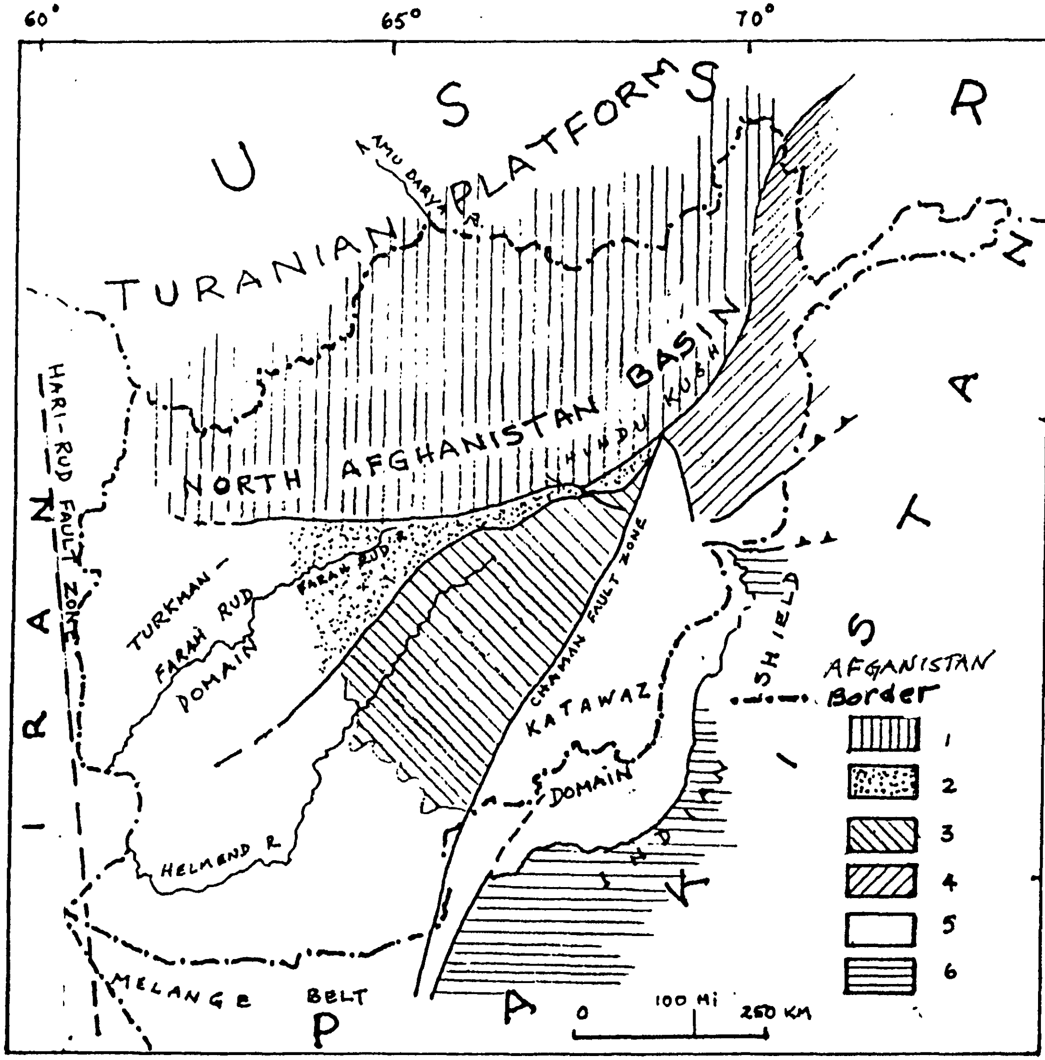

Figure 1.--Schematic sketch map of Afghanistan tectonics showing the North Afghanistan basin and the principal domains or terranes of Afghanistan separated by sutures: 1 = North Afghanistan basin, of the domain or terrane which is essentially the Afghan portion of the Turanian platform bounded on the east and south by an orogenic zone; 2 = the Turkman (or Farah Rud) domain or terrane is apparently separated from the adjoining terranes by ophioloite-bearing sutures representing closed oceans; 3 and 4 = terranes which may once have been a single block but broken by Chaman faulting; 5 = the Katawaz area may have been a separate terrane, but is now a tectonically complicated area with wrench faulting and thrusting and folding resulting from the collision with the India block; 6 = the finally arrived India block (modified from Boulin, 1981).

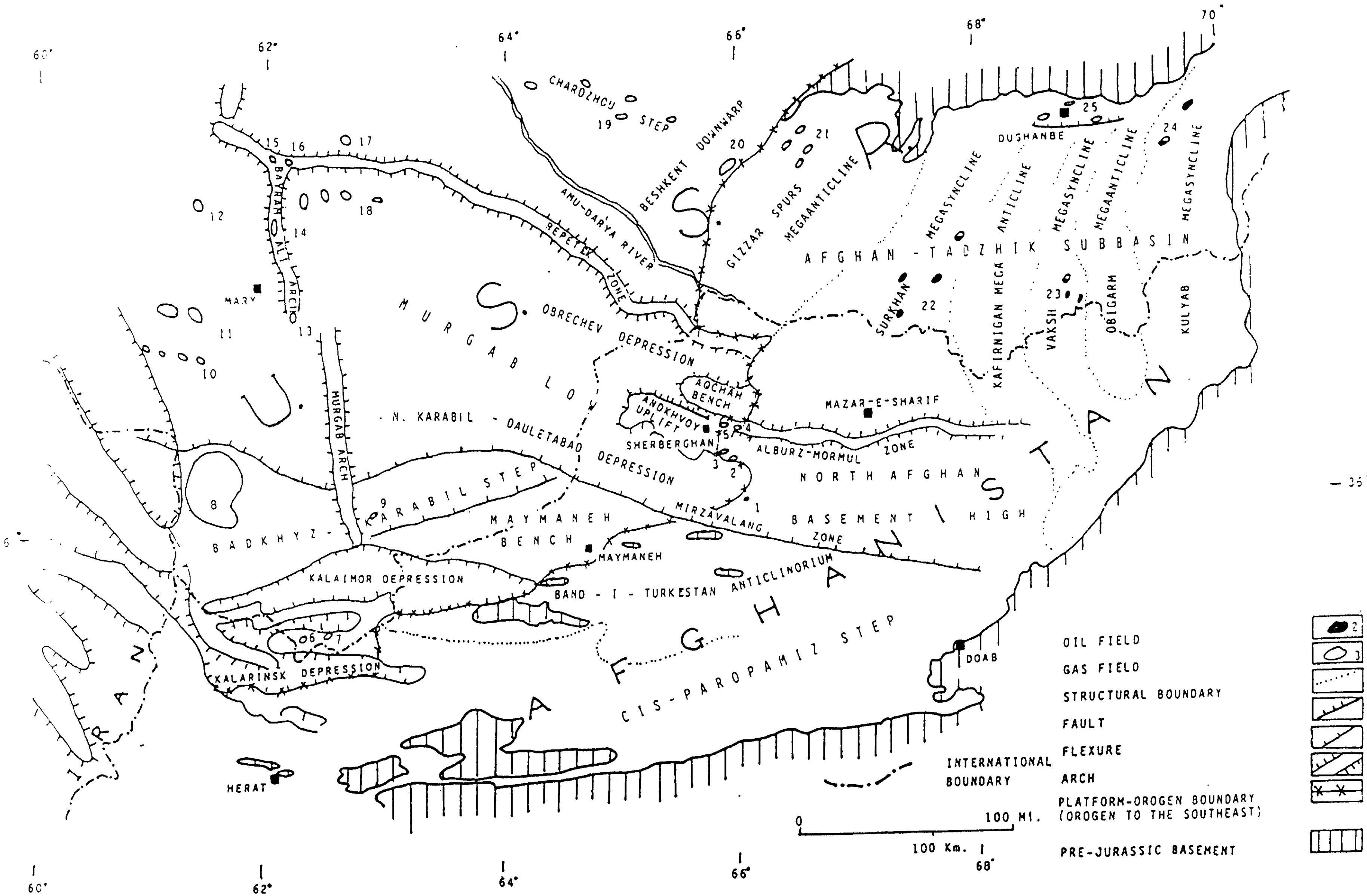

Figure 2.--Map of North Afghanistan basin and its northwestern continuation, the Amu-Dar'ya oil-gas province, in the USSR showing main tectonic units and principal oil and gas fields (based on Bratash and others, 1970). Oil and gas field identifying numbers refer to Table 1.

The sedimentary rocks of the North Afghanistan basin continue northwestward from Afghanistan into a large area of the USSR, some 140,000 mi^2 (360,000 km^2), where they form the Amu-Dar'ya oil-gas province. The southeastern third of the Amu-Dar'ya province is shown northwest of the Afghanistan-USSR boundary in figure 2.

HISTORY OF EXPLORATION OF THE NORTH AFGHANISTAN BASIN

Oil exploration began in 1929 in the Amu-Dar'ya basin, an oil-gas province of the Soviet Union, which adjoins and is geologically a continuation of the North Afghanistan basin (fig. 2). Exploration intensified in 1953 after discovery of the first gas field on the Chardzhou step of the Amu-Dar'ya province (no. 19, fig. 2, table 1). Exploration in North Afghanistan began somewhat later; the first drilling commenced in 1956, and the first oil and gas discovery, the Angut field (no. 1, fig. 2, table 1), was made in 1959. During the period 1959-66, 50 wildcats were drilled, resulting in the discovery of one small oil field (Angut, 1959) (no. 1, fig. 2) and three primarily gas field (Etym-Tag-1960, Khvajeh Gugerdak-1961, and Khvajeh Bulan-1964) (nos. 5, 4, 2, fig. 2, table 1). Details of further exploration are lacking but it appears that from 1966-81, two additional small oil fields and one large gas field, Dzhar-Kuduk (1971) (no. 3, fig. 2, table 1), plus at least two other small gas fields were discovered (Oil and Gas Journal, 1979, 1982). Most of the discoveries are limited to the northwest corner of the North Afghanistan basement high. By the beginning of 1974, discoveries of recoverable gas totaled some 3.5 tcf, with additional indicated reserves of 1.235 tcf, and recoverable oil reserves (probably including condensate) stood at about 80 million barrels (Escap, 1980).

In contrast, reserves of the adjoining region of Soviet Central Asia are 121 tcf, most of which are in the Amu-Dar'ya oil-gas province. The latest large discovery in Amu-Dar'ya, 40 miles north of the Afghanistan border, was the Dauletabad gas field, 50 tcf, of the Badkhyz-Karabil step (no. 8, fig. 2, table 1).

While the exploration of the Amu-Dar'ya province of the USSR appears to be in at least an early stage of maturity, the Afghanistan counterpart is not. The level of activity for an area of this size appears low. Until the beginning of 1979, reportedly only 4,800 mi (7,700 km) of seismic profile was shot and 958,364 ft (292,109 m) of wildcat hole was drilled (Escap, 1980) (about equivalent to a single rig drilling through the 20 years). Judging by the results of the first 50 wildcats drilled in northern Afghanistan, the success rate is low, about 8 percent. Apparently exploration has been much reduced since the Soviet invasion in 1980.

Table 1

Significant fields of the North Afghanistan basin and the adjoining area of Amu-Dar'ya basin, USSR

(from various sources, mainly Bratash and others, 1970, and Clarke, 1988)

Map number (fig. 2)	Field	Principally oil and gas	Principal reservoir	Gas reserves (partly available) tcf
Afghanistan				
North Afghanistan Basement High				
1	Angut	oil	Hauterivian sandstone	
2	Khvajeh Bulan	gas	Hauterivian sandstone	
3	Dzhar Kuduk	gas	Hauterivian sandstone	4.75
4	Khvajeh Gugerdak	gas	Hauterivian sandstone	(80 MMBO)
5	Etym-Tag	gas and oil	Hauterivian sandstone (x = plus U. Jurassic carbonate)	
USSR				
Kalaimor-Kalarinsk Foldbelt				
6	Islam	gas	U. Jurassic sandstone	3.1
7	Karachop	gas	Cretaceous sandstone	3.1
Badkhyz-Karabil Step				
8	Dauletabad	gas	L. Cretaceous sandstone	50.0
9	Karabil	gas	L. Cretaceous sandstone	1.2
Murgab Low				
10	Tedzhen Fields	gas	?	1.6
11	Shatlyk	gas	L. Cretaceous sandstone	_ 28.0
		gas	U. Jurassic limestone	?
12	Yelan	gas		
13	May	gas	L. Cretaceous sandstone	0.4
14	Bayram Ali	gas	L. Cretaceous sandstone	1.4
15	Sharapli	gas	L. Cretaceous sandstone ?	3
16	Keli	gas	L. Cretaceous sandstone ?	6
17	Malay	gas	L. Cretaceous sandstone	.036
18	Uchadzh Fields	gas	L. Cretaceous sandstone	5.4
Chardzhou Step				
19	52 fields	gas and oil	U. Jurassic limestone/ dolomite	47.6

Table 1 continued

Beskant Downwarp				
20	Shurtan	gas/cond.	U. Jurassic carbonate	13.0
Gissar Spurs				
21	4 fields	gas	U. Jurassic carbonate	3.3
Surkhan Megasyncline				
22	5 fields	oil	Paleogene carbonate	.04
Veksh Megasyncline				
23	3 fields	oil	Paleogene carbonate	?
Kulyab Megasyncline				
24	2 fields	oil	Paleogene carbonate	?
Dushanbe Graben				
25	3 fields	oil and gas	U. Jurassic carbonate	?

STRUCTURE AND TRAP AREA OF THE NORTH AFGHANISTAN BASIN

General

The principal tectonic trends of the North Afghanistan basin are shown on figure 2, and the configuration, i.e. depth to basement, on figure 3. The area of the basin is some 48,000 mi^2 (124,000 km^2) and its volume about 80,000 mi^3 (333,000 km^3).

The North Afghanistan basin is in part the southeastern extremity of the Turanian platform (fig. 4). The Turanian platform extends some 450,000 mi^2 (1,165,000 km^2) over southern USSR and eastern Iran. Its southern edge within Afghanistan is indicated on figure 2 by a barbed line. The platform's basement is pre-Jurassic and is made up of folded and faulted, and in some places metamorphosed, Early Triassic, Paleozoic, and older rocks. Upper Permian and Triassic rocks are present in minor rift basins that developed on this platform. Following a Triassic erosional break, platform deposition began in the late Triassic but largely in the Jurassic. The platform is transected by a number of regional, linear zones of faulting, narrow uplifts and flexures, which appear to represent reactivated basement faults or sutures, e.g. Repetek, Alburz-Mormul, and Mirzavalang zones (fig. 2). These major trends of the Afghanistan region have a preferred east-west orientation, perhaps subparallel to the edge of the original southern boundary of the Turanian platform before the region was distorted by the final Neogene collision with the India block.

Platformal sedimentary fill began essentially with the Jurassic and has continued to the present. Thickness changes in sedimentary units in various parts of the basin indicate continued tectonic movement. East-west fault zones bound a number of major fault blocks, generally stepping down to the north, e.g. the Cis-Paropamiz Bench, the North Afghan basement high, and the Afghan-Tadzhik subbasin (figs. 2 and 4).

As reflected by the sedimentation, the Turanian platform, though cut by a number of major fault zones, subsided somewhat uneventfully, but gently with little lateral facies changes in the sediments. The area was essentially unaffected by the continental collisions to the south until the arrival of the India block in early Neogene time. Only a narrow zone of the undisturbed Turanian platform, some 11,000 mi^2 (28,500 km^2) extends into northern Afghanistan.

The India block wedged forcefully northward passing Afghanistan on the east causing uplift and westward compression on the eastern margin of North Afghanistan basin. The uplifted area of 37,000 mi^2 (96,000 km^2) is in a zone from 80-135 mi (130-216 km) wide around the south and east perimeter of the Turanian platform; it comprises most of the North Afghanistan basin and has been designated the epi-platform orogenic zone (fig. 2).

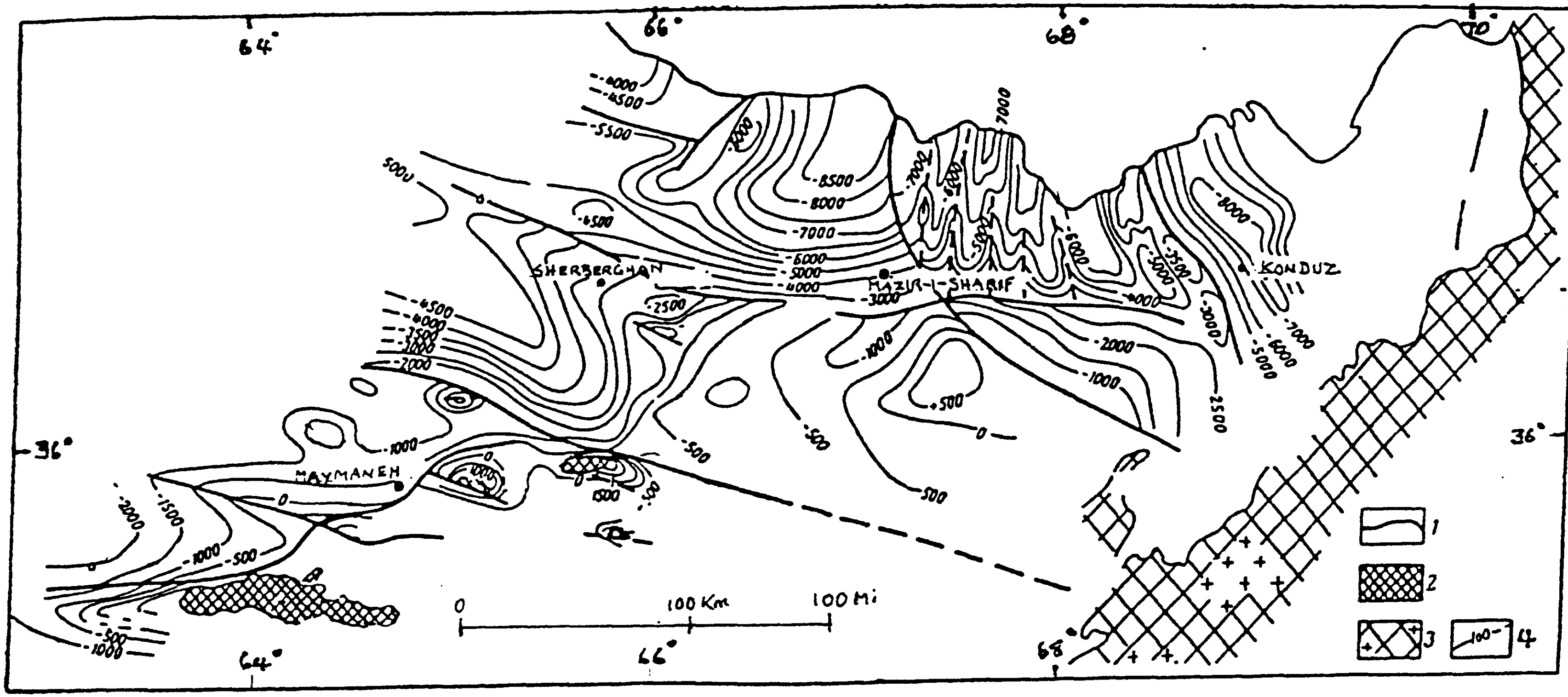

Figure 3.--Depth to basement map of the North Afghanistan basin. Economic basement assumed to be at base of the Jurassic rocks (after Bratash and others, 1970). 1 = fault and flexure lines, 2 = Triassic outcrops, 3 = exposed basement, and 4 = contoured depth to base of Jurassic rocks, in meters.

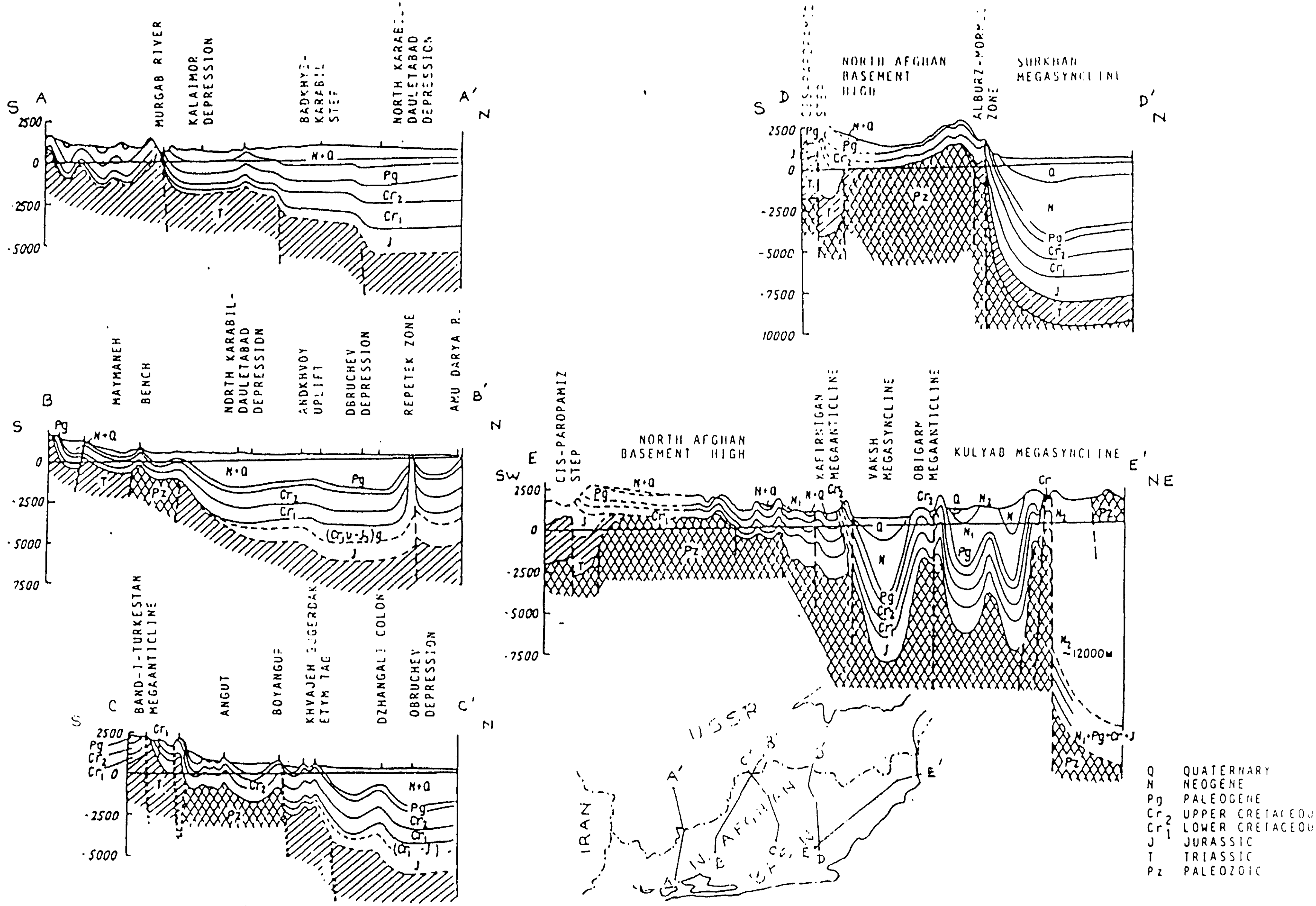

Figure 4.--North-south geologic sections across the North Afghanistan basin (from Bratash and others, 1970). Vertical scale in meters relative to see level.

Some of the east-west linear features that have been postulated as old reactivated faults, extend from the Turanian platform into the orogenic zone (fig. 2).

The effects of the west component of compression are most noticeable in the Afghan-Tadzhik depression or subbasin of Afghanistan and USSR (as defined by structural boundary lines, fig. 2) where a thick sedimentary section overlying a thick Upper Jurassic salt deposit yielded to the compression along the salt layer, resulting in disharmonic folding and thrusting in post-Jurassic sediments (fig. 5). Strike-slip and drag folds along the reactivated west-trending fault zones (e.g. Alburz-Mormul Zone) may have formed at this time (fig. 2).

Potential Petroleum Traps

Within the above described regional structural framework, there are numerous structural forms that make up potential petroleum traps. These structural traps are generally of two types: (1) high amplitude compressional, or drag, folds and diapirs with associated faults, and (2) low-amplitude platform drapes or tilted fault block, features caused by continuing differential fault movements.

The high-amplitude folds are largely confined to the Afghan-Tadzhik subbasin (fig. 5), but drag folds may occur along some of the regional fault zones where strike-slip movement is likely, e.g. the Alburz-Mormul fault zone. The compressional folds of the Afghan-Tadzhik subbasin appear superficially to be similar to other fold belts of the world involving rather plastic Mesozoic-Tertiary sediments. The mode, however, is altered by the presence of Jurassic salt that has entered the cores of some of the anticlines in the eastern part of the basin. The structure of the Afghan-Tadzhik subbasin, though consisting largely of folds, is partially controlled by the fault block structure of the basement and by numerous reactivated faults (fig. 5). According to Makhkamov and others (1981), deposition within the subbasin during Mesozoic and Paleogene time was laid down on a subsiding platform environment with little local syndepositional tectonics. It was not until the Alpine (Miocene to recent) orogenic compression that folding of the thick plastic basin-fill was accompanied by local, associated abrupt facies and thickness changes and unconformities. The Upper Jurassic salt acted as a sole along which horizontally displaced high-amplitude folds and thrusts moved, forming complex disharmonic structure in the post-salt sediments unrelated to the low-amplitude, fault-controlled, platform tectonics of the pre-salt beds (fig. 5). Kravchenko and others (1983) indicated that 95 structures had been catalogued for the Soviet part of the Afghan-Tadzhik subbasin exclusive of the Surkhan megasyncline. Their map indicates that the area of 71 mapped traps constitutes 11.6 percent of the basin area. If this percentage is applied to the Afghanistan portion of the Afghan-Tadzhik basin, plus the Gissar Spurs province, of 12,700 mi^2 (32,900 km^2), a trap area of some 1,470 mi^2, or 940,000 acres (3,800 km^2), is indicated. In the rather maturely explored area of the Soviet portion of the basin, eight petroleum fields have been

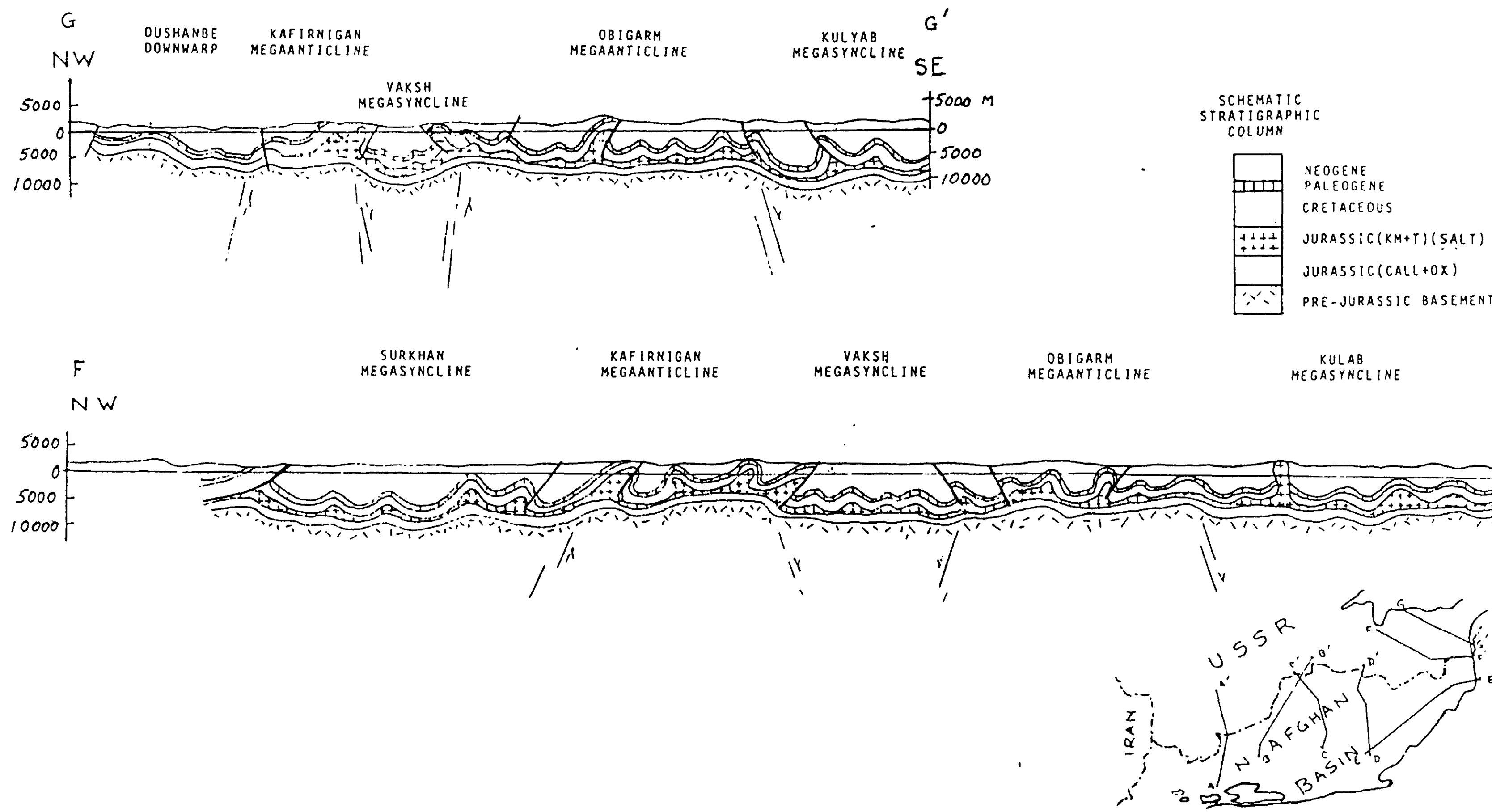

Figure 5.--East-west geologic sections across the Afghan-Tadzhik subbasin (from Bratash and others, 1970). Vertical scale in meters relative to sea level.

discovered giving a success rate of 12 percent. In the entire Soviet portion of the Afghan-Tadzhik basin, there are 170 local highs, half of which have been drilled resulting in 16 discoveries (Levitskiz, 1980) giving a success rate of 18.8 percent. These wildcats were drilled largely on post-salt features and the success rate and area of closure only applies to the post-salt plays.

Little information concerning the details of the structure on the Turanian platform of Afghanistan is available. However, an analog is provided by the old oil-gas region located on the Karabil downwarp of the Chardzhou tectonic step forming the north flank of the Amu-Dar'ya depression and which is some 110 miles northwest of the USSR-Afghanistan border (number 19, fig. 2). According to Sokolov and Zelinen (1979), almost all the known traps of this area of any significant size have already been explored or are being explored. Almost all the gas and oil accumulations of the area are on early folds that grew gradually during the entire period of deposition of the sedimentary section. Consequently, the trap amplitudes increase with depth. In most cases, these structures experienced further growth in the Miocene to recent orogeny. The amplitudes of these structures are low with inferred dips of less than 10°. A map of these structures shows a random distribution and trend which suggests the folds to be essentially fault-controlled drapes and fault traps. According to Sokolov and Zelinen's map, the area of the traps, including leads, make up some 8.7 percent of the play area. Their map also shows that 38 percent of traps are occupied by oil or gas. Applying the 8.7 percent trap area value to the platform region of Afghanistan which has sufficient Jurassic cover, namely the Murgab low, of some 5,368 mi^2 (3.44 MMA), there is 467 mi^2 (.30 MMA) of trap area.

Jurassic strata also underlies the Afghan-Tadzhik basin and the adjoining Gissar Spurs province. This region was essentially a block-faulted, deep platform until the Miocene to Quaternary westward compression caused the thick Cretaceous and Tertiary beds to yield by disharmonious folding and faulting, the sole of which is the Upper Jurassic salt (fig. 5). The subsalt Jurassic and older strata probably retain the faulted platform-type structure. The percentage of trap area versus the total play area, i.e. 8.7 percent of the platform region, may be applied here to the pre-salt Jurassic strata. This would indicate that the Afghan-Tadzhik subbasin and adjoining Gissar Spurs province, with an area of 12,700 mi^2 or 8.13 MMA, has a total pre-salt trap area of some 1,105 mi^2 or 707,000 acres.

STRATIGRAPHY OF THE NORTH AFGHANISTAN BASIN

General

The general stratigraphy is summarized in figure 6. Only the salient factors concerning petroleum generation and accumulation will be discussed.

Triassic

Triassic and older sedimentary rocks have been involved with the tectonics accompanying the collision with the Turkman block. These mildly metamorphosed rocks are considered part of the effective basement as concerns petroleum. The uppermost part of the Triassic sediments (T_3) are continental deposits of limited extent, usually in isolated grabens, which rest unconformably on eroded Paleozoic rocks. Triassic rocks have no role in petroleum accumulation either as source or reservoir.

Jurassic

The Lower Jurassic (J_1) strata are largely continental clastics containing coal-bearing shale and some volcanics (fig. 6). The Middle Jurassic (J_2) is an upward continuation of the clastics, becoming finer grained upwards; this may be one of the principal zones of source rocks. The Lower and Middle Jurassic section is about 3,000 ft (1,000 m) thick at the north border of Afghanistan, thinning southward (fig. 7).

The Upper Jurassic, i.e. the Callovian, Oxfordian, Kimmeridgian, and Tithonian strata make up the prime petroleum-producing section of the region (fig. 8). Carbonates of the Callovian, and principally Oxfordian age, are one of the main reservoir groups of the basin. Overlying Kimmeridgian and Tithonian salt and anhydrite provide effective seals (figs. 6, 7, and 8).

The Jurassic strata occur mainly in the Murgab depression (i.e. Obrechev, Aqchah, Andkhvoy, and Karabil-Dauletabad structural provinces and the Afghan-Tadzhik subbasin (figs. 2, 3, and 4). They are largely missing from most of the North Afghanistan basement high, the Maymaneh high, the Band-i-Turkestan megaanticline, and the Cis-Paropamiz blocks. The southward thinning of the Jurassic rocks against the northern flanks of the North Afghanistan basement high and the Maymaneh highs may provide stratigraphic traps. Isolated thick sections of continental Lower and Middle Jurassic rock occur along the south rim of the North Afghanistan basin in local grabens.

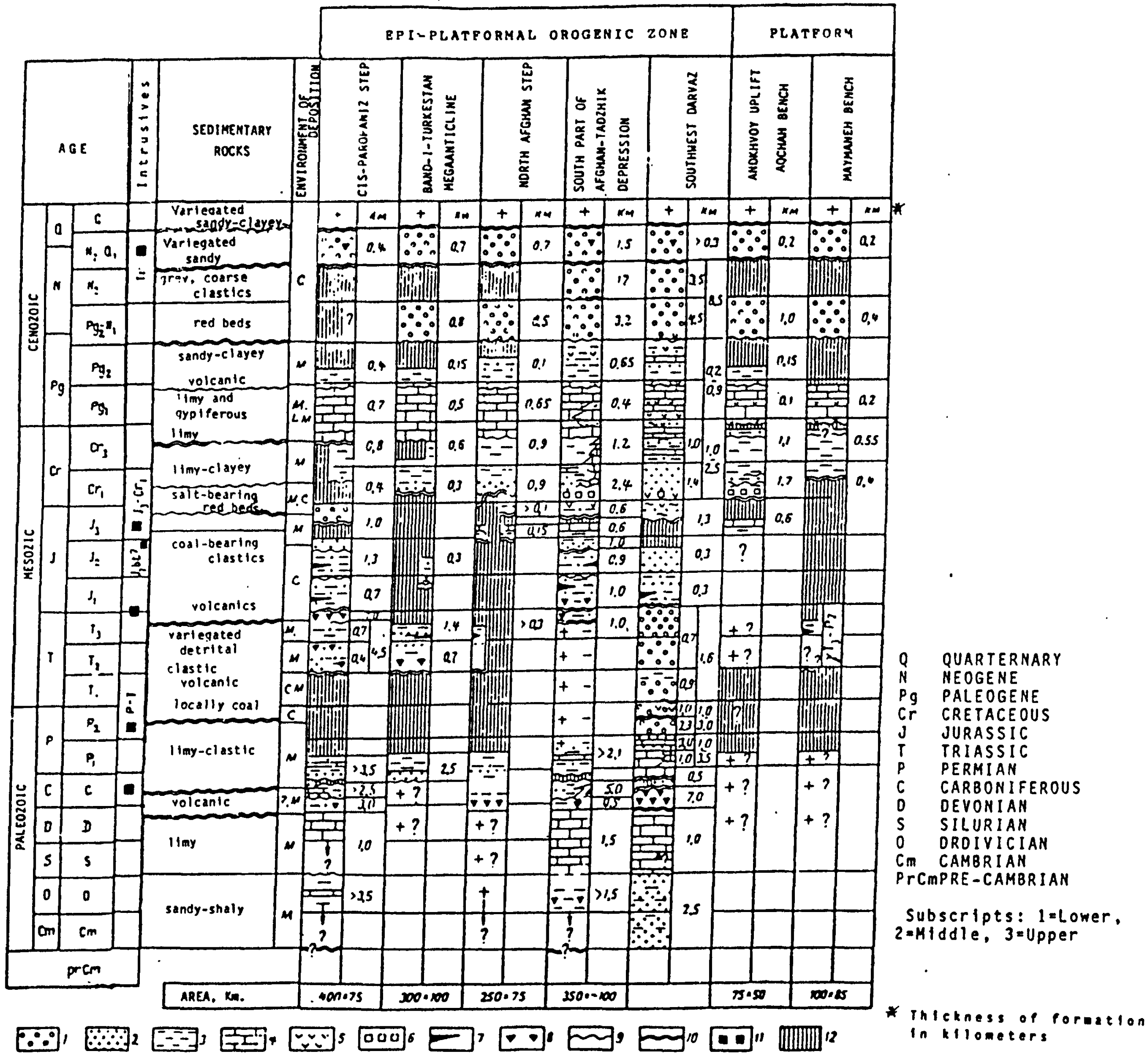

Figure 6.--Stratigraphic columns of North Afghanistan basin and vicinity (from Bratash and others, 1970). 1 = molasse, 2 = sandstone, rarely conglomerate, 3 = clays or shales, 4 = carbonate, 5 = gypsum, anhydrite, 6 = salt-bearing rock, 7 = coal-bearing rock, 8 = volcanic and pyroclastic rock, 9 = stratigraphic discordance, 10 = angular unconformity, 11 = intrusive activity, 12 = sediments absent.

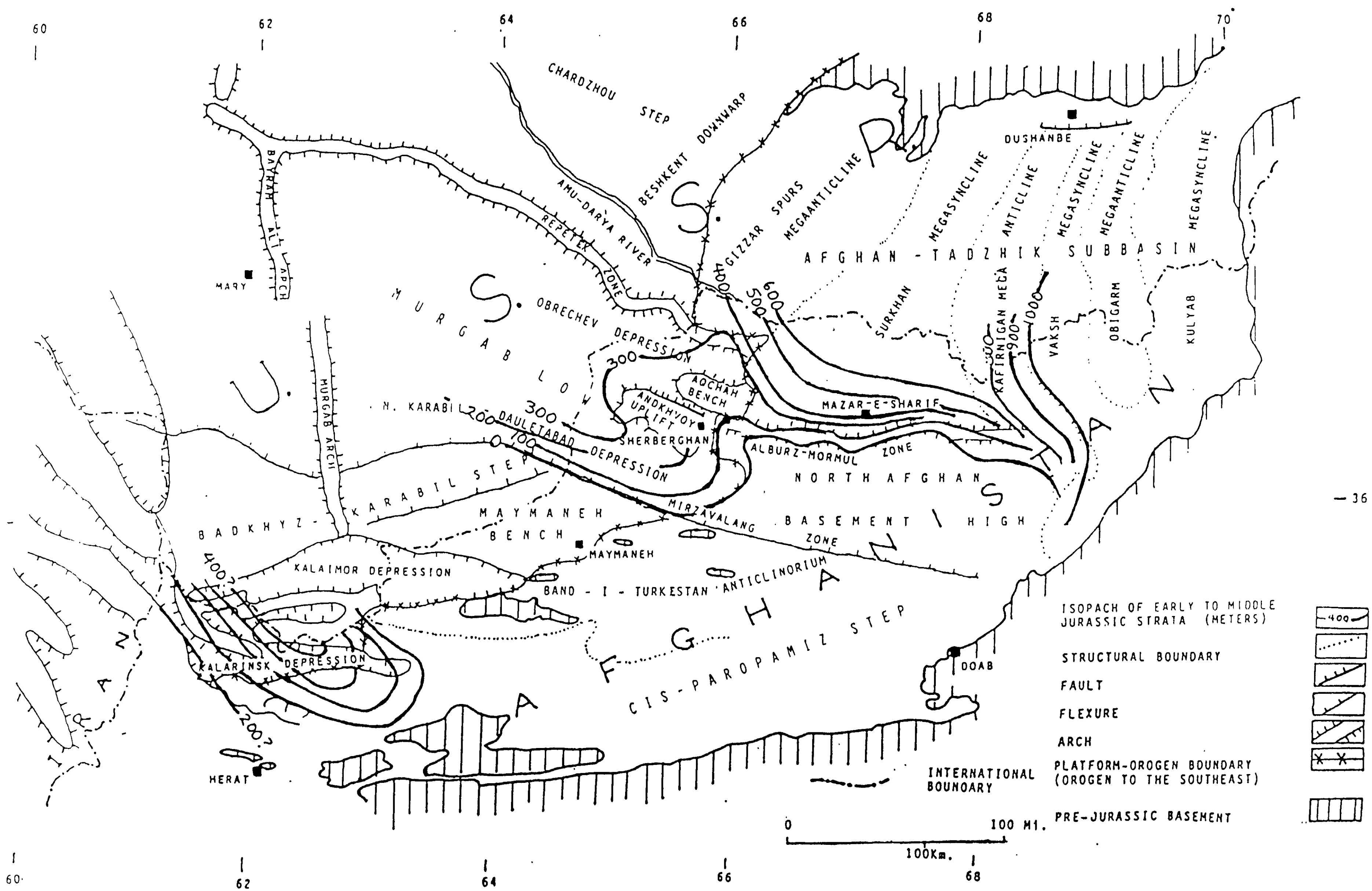

Figure 7.--Isopach map of Jurassic source rock (based on Bratash and others, 1970). Isopachs in meters.

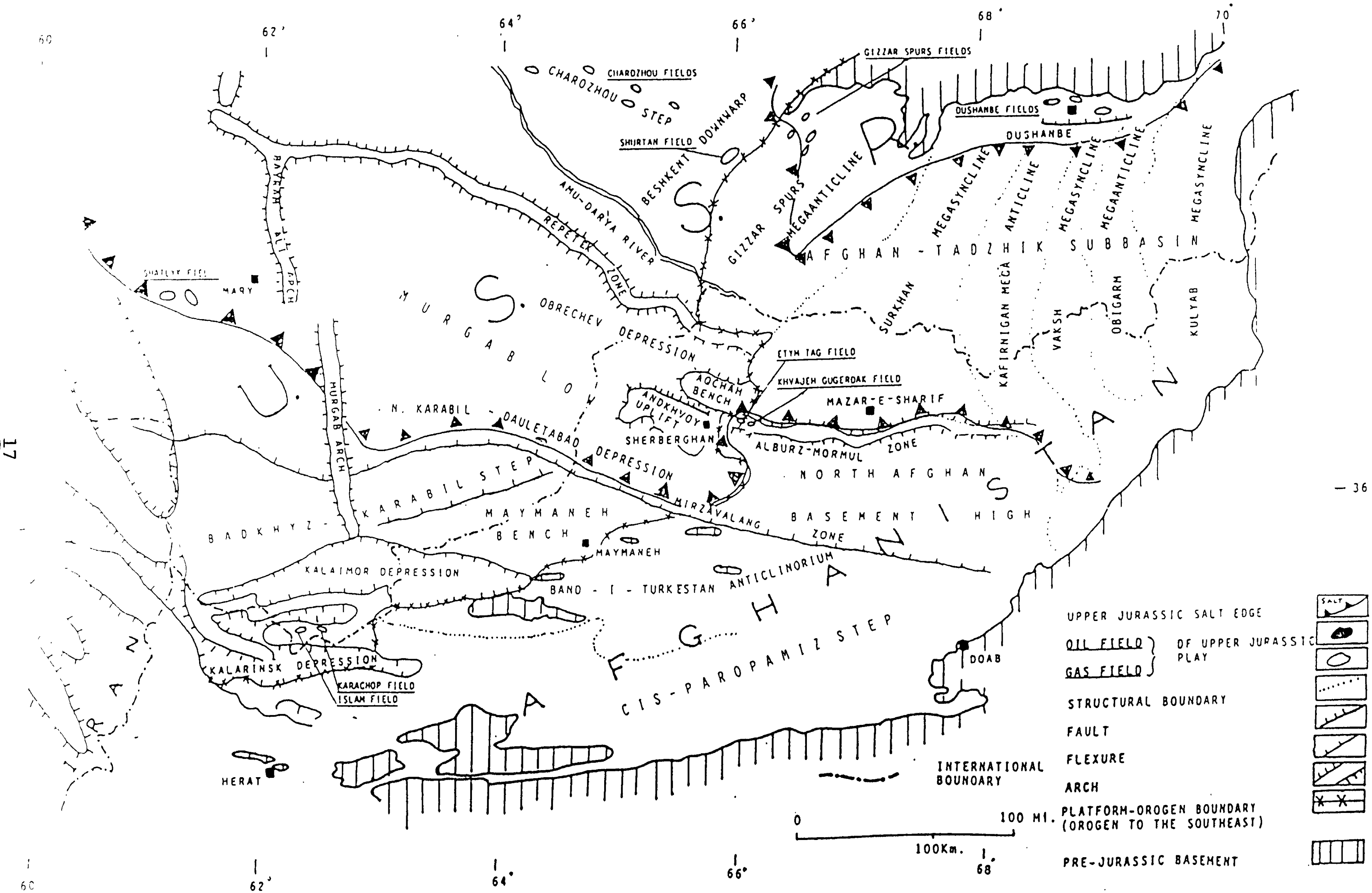

Figure 8.--Upper Jurassic play map showing tectonic trends in Upper Jurassic reservoirs and extent of Upper Jurassic salt (from Bratash and others, 1970).

Cretaceous

The Cretaceous strata of the Amu-Dar'ya oil-gas province (USSR) have been divided into a number of units based largely on paleontology. The Lower Cretaceous section consists of 4,000 ft (1,200 m) of clastic and carbonate rocks of marine and lagoonal-continental origin containing some evaporites. The Neocomian is mainly carbonates and shales except for the lower Hauterivian, which is largely redbed siltstones and sandstones up to 460 ft (140 m) thick; it is sealed by 230 ft (70 m) of shales, siltstones, carbonates, and 500 ft (152 m) of limestone and clay. Hauterivian sandstones of the Hauterivian Shatlyk horizon are the main reservoirs of the region, their extent is indicated on figure 9.

As much as 2,200 ft (670 m) of Aptian and Albian rocks, largely carbonates and shale with siltstones, are above the Neocomian.

The Upper Cretaceous is made up of as much as 5,000 ft (1,500 m) of carbonates, shales, and siltstone with some sandstone in the upper Turonian. The sandstone is some 260-370 ft (80-113 m).

The Cretaceous strata were deposited in a differentially subsiding basin. The Lower Cretaceous sedimentary strata are relatively thick in the Afghan-Tadzhik subbasin (including the Gissar Spurs), the north flank of the North Afghan basement high, and in the Murgab depression as may be seen in figure 4. Upper Cretaceous sedimentary rocks fill the same basinal areas and extend south over most of the Turanian platform beyond the Murgab depression, i.e. the Maymaneh high, the Kalaimor depression and fold belt, and the Kalarinsk depression. Upper Cretaceous sediments also extend over a major part of the North Afghan basement high.

Paleogene

Deposition continued without interruption from the Mesozoic into the Cenozoic over most of the North Afghanistan basin (figs. 4, 6, and 10). The lower Paleogene (PG_1), similar to the uppermost part of the Cretaceous, is made up largely of carbonates, evaporites, and shale. Paleogene sediments are extensive, covering all of the structural provinces and subbasins of the North Afghanistan basin. Lower Paleogene carbonates form prominent outcrops over the region except where they are buried in the Surkhan, Vaksh, and Kulyab megasynclines. These carbonates are overlain by upper Paleogene (PG_2) sandy claystones and shales up to 2,000 ft (610 m) thick.

Neogene

Unconformably above the upper Paleogene sandy claystones are coarse Neogene clastic sediments. They have no role in petroleum accumulation and are not considered further.

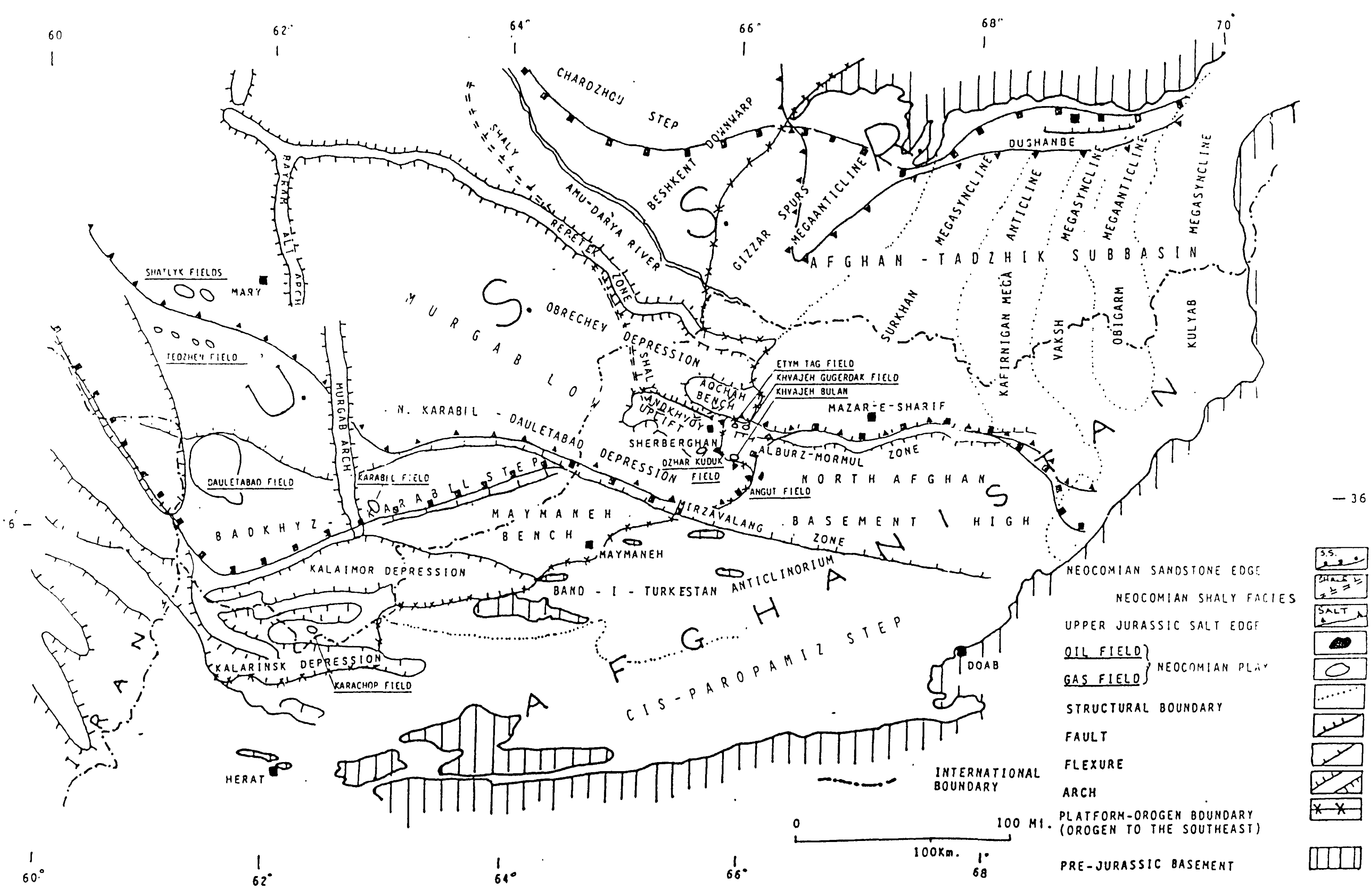

Figure 9.--Neocomian play map showing tectonic trends, fields in Neocomian reservoirs, extent of Hauterivian sandstones, and extent of Upper Jurassic salt (based on Bratash and others, 1970).

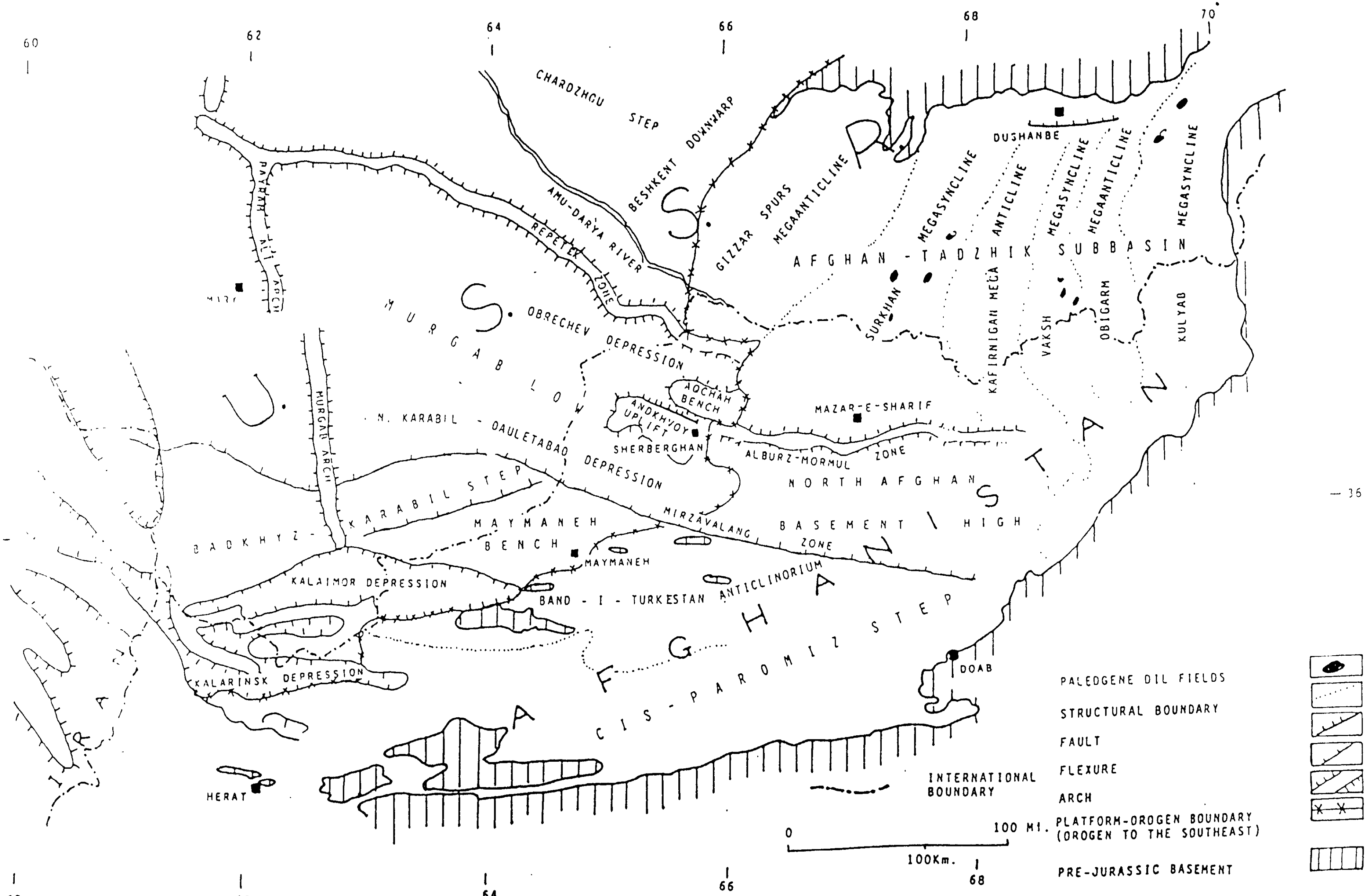

Figure 10.--Paleogene play map showing tectonic trends and fields in Paleogene reservoirs (from Bratash and others, 1970).

Principal Reservoirs

Jurassic

At the Khvajeh Gugerdak field a 2,500-ft (760 m) section of dark gray highly fractured Callovian-Oxfordian limestone is overlain by Kimmeridgian-Tithonian gypsum, dolomite, and anhydrite; as much as 85 ft (26 m) was considered productive (Majeed and Aurah, 1967). "Good" porosity and permeability are reported for Cretaceous and Jurassic reservoirs together, but data are given only for the Cretaceous reservoirs; assuming both sets of reservoirs are about the same, Jurassic porosities would range from 9 to 14 percent.

No other Callovian-Oxfordian detailed reservoir data are available in Afghanistan, but some data from the adjoining USSR may be applied (Clarke, 1988). The Adam Task field of the Gissar Spurs area, Afghan-Tadzhik basin (no. 21, fig. 2) has two zones, 360 ft (110 m) and 260 ft (80 m) thick, with porosities of 3.15 (non-producible) and 11.6 percent, respectively. The nearby Gumbalak field of the Gissar Spurs has reservoir thickness ranging from 120-290 ft (37-88 m) with porosities ranging from 9.6 to 16.0 percent. No reservoir information from the Murgab depression is available; the nearest field to the depression (which does not have reefal buildup) appears to be the Malay field (no. 17, fig. 2) which has 41 ft (12.5 m) of reservoir with 11 percent porosity. Averaging the parameters of these analog reservoirs, it is estimated that the Callovian-Oxfordian reservoirs in undiscovered fields would have an effective thickness of 40-400 ft (12-122 m), averaging 200 ft (61 m) and porosities ranging from 9 to 20 percent, averaging 15 percent.

In addition to the Callovian-Oxfordian reservoirs, some reservoirs are present in the Lower Jurassic section of westernmost Afghanistan. The Islam field in the USSR immediately north of the border of western Afghanistan (no. 6, table 1 and fig. 2) produces gas from some 160 ft (50 m) of sandstone. The sandstone has poor reservoir properties (porosity of 7.7 percent) and the yield is small (Clarke, 1988).

Three small fields, Shaambury, Andigon, and Komsomol of the isolated Dushanbe area (no. 25, fig. 2) produce small amounts of gas from Tithonian clastic reservoirs.

Cretaceous

The main reserves (97 percent) in the Cretaceous System are in sandstone of the Hautervian Stage. In the Khvajeh-Gugerdak field (no. 4, fig. 2), the reservoir is a red continental sandy-silty member some 460-525 ft (140-160 m) thick with an effective thickness of 285-330 ft (87-100 m) (Bratash and others, 1970). Porosity ranges from 6 to 14 percent and permeability from 100 to 600 md. In other fields, the effective thickness appears to be less. For evaluation purposes, we assume these reservoirs in future fields of the area will average 150 ft (46 m) thick.

This sand-silt member is regionally persistent and is the principal producer of adjoining Amu-Dar'ya oil-gas province of USSR, where it is referred to as the Shatlyk Horizon. In the Karabil field (no. 9, fig. 2) the Shatlyk Horizon has a producing thickness of 72 ft (22 m) and in the giant Dauletabad gas field, some 58 ft (18 m). The Shatlyk sandstone reservoir does not extend with any appreciable thickness south of the Badkhyz-Karabil step and appears to shale out east of a southeast-trending line through the Murgab low (fig. 9).

Minor reservoirs are higher in the section; they are thin (15-20 ft, 5-6 m) sandstones in the Aptian and Albian and are characterized by low yields.

Maastrichtian to Danian carbonates of the Upper Cretaceous provide the principal reservoirs of the Karachop and Islam fields (nos. 7 and 6, fig. 2) of the USSR immediately adjoining Afghanistan on the north (table 1 and fig. 2).

Since an estimated 97 percent of Cretaceous entrapped oil and gas is in Hauterivian sandstone, the area of viable Cretaceous play is limited to those parts of the basin where Neocomian sediments have accumulated, i.e. the Afghan-Tadzhik subbasin plus adjoining Gissar Spurs and north flank of the North Afghan basement high and the Murgab low (fig. 9).

Paleogene

The main Paleogene reservoirs are in carbonate rocks. In the Afghan-Tadzhik subbasin, a number of oil fields (figs. 2 and 10) have been found in the Soviet portion. The only reservoir data available are from one field, Lyal-Mikar, where the lower Paleogene limestone resource interval and possibly the underlying Upper Cretaceous are 181 ft (55 m) thick and average porosity is 18 percent (Clarke, 1988). To the west-southwest in the Karabil field (no. 9, fig. 2), there are 33 ft (10 m) of lower Paleogene carbonate reservoir, which have a porosity of 16 percent. For evaluation purposes, we are assuming an average net reservoir thickness of 100 ft (35 m) and average porosity over the area of 17 percent for the Paleogene reservoirs.

Source Rock

Little data are available concerning source rocks in Afghanistan, but studies of source richness of the Turanian platform have been made in the USSR (Chetverikova and others, 1982). Four source bed complexes are recognized in the Mesozoic section. Of the total hydrocarbons yielded by these source beds, 75 percent are from the Lower Middle Jurassic, 10 percent from the Callovian-Oxfordian, 1 percent from the Neocomonian, and 14 percent from the Aptian-Albian rocks.

The Lower-Middle Jurassic source rock section is the thickest and occurs in two areas. One area is located north of the Karabil step-Maymaneh bench trend and the North Afghan basement high. Thickness increases northeastward into the Afghan-Tadzhik subbasin to approximately 3,280 ft (1,000 m). The second area is in the southwest corner of the basin where the Lower-Middle Jurassic section thickens to 1,300 ft (400 m) (fig. 7). The Lower-Middle Jurassic source rocks are also the richest. Throughout most of the Turanian platform in the USSR these beds are largely continental, but in the east and adjoining Afghanistan they include some nearshore marine sedimentary rocks. The silt-clay rocks of the continental facies contain 1.2 to 1.5 percent humic type organic matter. The nearshore marine facies are equally rich in organic matter. These source beds are 330-1,800 ft (100-550 m) thick and compose about 60 percent of the Lower-Middle Jurassic section.

The Callovian-Oxfordian rocks of the Turanian platform adjoining Afghanistan are largely carbonate shelf deposits, and reef facies predominate. The shales have a low content of humic organic matter, and the carbonate rocks contain very small amounts of sapropelic material. The thickness of these Callovian-Oxfordian source beds is 130-330 ft (40-100 m) in the central part of the Turanian platform and 490-920 ft (150-280 m) in the area adjoining Afghanistan.

The Neocomian strata are of a shallow-water, nearshore environment and are low in organic matter.

The overlying Aptian-Albian strata are largely clastic rocks. Content of organic carbon is 1.1 to 1.3 percent in clays, 0.5 to 0.8 percent in siltstone, and 0.3 to 0.5 percent in sandstone.

Seals

The distribution and efficiency of the Upper Jurassic evaporite seal is critical because it is a barrier between the primary source rock, Jurassic shales, and the primary Neocomian and Paleogene reservoirs. As may be noted from figure 9, the large Neocomian gas fields of the USSR are located outside and at the edge of the Jurassic salt area, e.g. Karabil, Dauletabad, Shatlyk (nos. 9, 8, 11, fig. 2) and others, as are smaller Afghanistan fields, Khvajeh Gugerdag, Angot, Dzhak Kuduk (nos. 4, 1, 3, fig. 2) and others.

No large gas or oil accumulations have been found in post-Jurassic rocks in the areas where Upper Jurassic salt is present, but smaller fields do occur, however, as for example the oil and gas fields of the Afghan-Tadzhik subbasin. More discoveries may be expected not only in the Afghan-Tadzhik subbasin but also in the Murgab low. These accumulations would have been generated only from the relatively meager Aptian-Albian to Paleogene source shales and would be small.

Cretaceous and Tertiary shales form seals over the Cretaceous and Paleogene reservoirs. These seals are only moderately efficient especially in the fold area of the Afghan-Tadzhik subbasin. Here the oil and gas fields occur only in the megasynclinal areas where the Neogene shale appears to be sufficiently thick to seal the Paleogene reservoirs.

GENERATION AND MIGRATION OF OIL AND GAS

Depth and Volume of Thermally Mature Rocks

The average thermal gradient in producing wells of the North Afghanistan basement high area is about 1.9°F/100 ft (34.6°C/km) (Bratash and others, 1970). This gradient is considered to be the average of the North Afghanistan basin. Assuming the thermal gradient has been stable since the early Mesozoic, it would appear from rough calculations that: (1) the Jurassic strata are largely in the thermal gas window in all the basinal areas; (2) Cretaceous strata are in the thermal gas window in the deeper parts of the Afghan-Tadzhik depression, but are partly in the oil window on the basin perimeter and in part in the Turanian platform area; and (3) Paleogene (and some Neogene) strata are in the oil window on the basin perimeter. If so, the volume of mature and over-mature rocks in the Turanian platform area is 10,500 mi^3 (44,000 km^3), and in epi-platform orogenic zone this volume is 28,500 mi^3 (119,000 km^3).

Oil Versus Gas

The North Afghanistan basin as well as the adjoining Turanian platform of the USSR is gas prone. The reasons for this is that 85 percent of the hydrocarbons were generated from Jurassic source rocks, which contain largely humic organic matter and occur in the thermal gas window in most of the basin.

One small oil field, Angut (Cretaceous) (no. 1, fig. 2), and several minor Paleogene oil fields on the USSR side of the Afghan-Tadzhik depression are the only oil discoveries to date. The Angut oil is sulfurous, tarry, waxy, suggesting it was biodegraded and probably sourced from shallow depth (oil-window) Jurassic sediments on the perimeter of the Afghan-Tadzhik depression. The Paleogene oil may have been generated from Paleogene or Cretaceous strata sufficiently shallow to be within the oil window.

In any case, oil is of minor importance in this basin. For assessment purposes we are assuming that only 5 to 10 percent of the hydrocarbon is oil, except for the shallow Paleogene accumulation, which may be 50 percent oil.

The gas of the area appears to be dry; the only available data concerning condensate yield (barrels of natural gas liquid per million cubic feet of nonassociated gas, BNGL/MMCFG), are for the nearby Dauletabad gas field (no. 8, fig. 2). There the condensate content of the gas is 3.9 BNGL/MMCFG. In the absence of any other data, this is assumed to be average for the reservoirs above the Kimmeridgian evaporite. The reservoirs below the Kimmeridgian evaporite, however, are assumed to contain some 25 BNGL/MMCFG of condensate, supported in part by the 35 BNGL/MMCFG of the Adamtash field of the Gissar Spurs area (no. 21, fig. 2) of USSR.

Migration Timing Versus Trap Formation

Assuming that the thermal gradient was more or less constant, oil generation and migration would not begin until burial depth reached about 7,500 ft (2,300 m) in the central part of the basin. This burial depth would have been reached in about the early Cretaceous. On the perimeter of the basin where subsidence was slower, oil-generating maturity of the source shales was not reached until the Tertiary. Gas generation in the central basin areas probably began in the late Cretaceous, but reached its maximum in the Neogene when the Himalayan (Alpine) orogeny caused maximum subsidence.

Two generations of traps seem to be present. The earliest traps are low amplitude drapes or fault traps of the Turanian platform. These closures are drapes over basement fault blocks or are results of differential movements along old faults. This kind of structure has been well explored in the West Uzbekistan oil-gas region (Chardzhou step, number 19, fig. 2). Closure on these old structures attenuates upwards, the amplitudes decreasing from a maximum on the Jurassic strata to almost zero on the lower Tertiary. These traps are expected to contain oil and gas pools in the Jurassic to Lower Cretaceous rocks.

The younger traps are those attributed to Himalayan (Alpine) orogeny associated with the collision of India with the Asian land mass. Trap formation probably began in early Neogene and continues to the present, possibly peaking in the Pliocene. Basin subsidence also reached a maximum at the same time.

With the above events in mind, it would appear that the first phase of oil and gas generation began early in the Cretaceous and continued to late in the Cretaceous, during which time interval the principal source rock, Lower and Middle (and less rich Upper) Jurassic, was passing through the oil window. By analogy to West Uzbekistan, reservoirs as well as closures could be expected to have been already in place to receive any migrating petroleum.

In the Neogene, subsidence accelerated so that most of the Jurassic strata, and in the deeper basin the Cretaceous, entered the thermal gas window. Any oil accumulation under the Upper Jurassic evaporite seal was probably cracked to gas. The only available petroleum would be that sourced from the shallower, relatively minor Cretaceous and Tertiary source rock.

PLAY ANALYSIS

The geology of the North Afghanistan basin indicates a number of hydrocarbon plays. Five plays are assessed to have more than 95 percent of the hydrocarbons. These five plays, shown on figures 8, 9, and 10, are defined by the prospective reservoirs and by traps described in some detail above. As a recapitulation and evaluation of the geologic conditions favorable to hydrocarbon accumulation, the plays are briefly summarized and analyzed in tables 2 through 6. As outlined in the Introduction, these play analyses quantify the relevant favorable factors and arrive at an estimate of petroleum in each play. The five plays are:

1. Upper Jurassic drapes, area of 11.6 MMA
2. Neocomian drapes, area of 3.44 MMA
3. Folded Neocomian reservoirs, area of 9.10 MMA
4. Folded Paleogene reservoirs, area of 8.13 MMA
5. Western fold belt, area of 2.45 MMA

The total estimated undiscovered recoverable petroleum in these five plays (tables 2 through 6) amounts to 300 million barrels of oil, 9.6 tcf of gas, and 145 million barrels of condensate.

CONCLUSIONS

1. Significant undiscovered petroleum in Afghanistan is limited to the North Afghanistan basin area of some 48,000 mi^2 (124,000 km^2) adjoining the USSR.

2. Oil and gas reserves discovered to date are small, amounting to 80 million barrels of oil and 4.74 tcf of gas.

3. The structure of the North Afghanistan basin consists of two provinces: (1) the southward extension of the Turanian platform, and (2) the epi-platform orogenic zone, a faulted and folded area south and east of the platform formed by the Neogene collision with the Indian sub-continent. The orogenic zone comprises some 77 percent of the basin area within Afghanistan.

4. Essentially two types of traps are encountered: (1) old, low-amplitude platform drapes or fault traps, and (2) high-amplitude Neogene compression drag folds, including thrust-faulted, diapiric, and decollement folds.

5. There are three principal zones of reservoirs: Callovian-Oxfordian carbonate rocks, Hauterivian sandstones, and Paleogene carbonate rocks. The Hauterivian sandstones are the principal and best-quality reservoirs of the Turanian platform. However, these reservoirs thin and shale-out toward Afghanistan, which is probably the main factor in the lower oil and gas potential of the North Afghanistan basin. The poorer, less-developed Callovian-Oxfordian carbonate reservoirs may have the highest potential, owing to their

stratigraphic position adjacent to source rock and beneath the principal regional seal.

6. The principal source rock is the Lower, Middle, and Upper Jurassic shale. In the adjoining USSR this shale generates 85 percent of the oil and gas. Minor source strata appear to be in the Cretaceous and Paleogene sections.

7. Critical to the formation of larger hydrocarbon deposits in the region has been the distribution of the Kimmeridgian evaporites, which act as a barrier between the Jurassic source rocks and the well-developed Lower Cretaceous reservoirs and Neogene traps.

8. At least five separate plays can be recognized in the North Afghanistan basin. Of these, the deep play beneath the Jurassic salt is deemed to have the highest potential, providing reservoirs are adequate.

9. The undiscovered recoverable petroleum in Afghanistan is estimated to be 300 million barrels of oil, 9.6 tcf of gas, and 145 million barrels of condensates.

Table 2

Play Analysis Summary of Undiscovered Petroleum

Basin North Afghanistan No. 1 Country Afghanistan Play Upper Jurassic Drapes No. 1
Area of basin (mi^2) 48,000 Area of play (MMA) 11.6
Volume of basin (mi^3) 80,000 Play est. orig. reserves 0 BBO 0 TCFG
Estimate original reserves .08 BBO 4.74 TCFG
Tectonic classification of basin: Foredeep plus collision zone
Definition and area of play: Limited to area of sufficiently thick Jurassic deposition and of evaporite coverage, namely, the Murgab low, of 3.44 MMA and the Afghan-Tadzhik subbasin of 8.13 MMA, giving a total play area of 11.6 MMA.

	MAJOR GEOLOGICAL/EXPLORATION FACTORS	PROBABILITY DISTRIBUTION 95%	MOST LIKELY	5%
A.	Untested trap area (MMA)	.01	.66	.85
B.	Percent untested trap area productive (%)	2	5	10
C.	Average effective pay (feet)	50	200	400
D.	Percent oil versus gas in petroleum fill (%)	1	5	200
E.	Oil recovery (BBLS/AF)	150	212	350
F.	Gas recovery (MCF/AF)	700	800	1,000
G.	NGL recovery (BBLS/MMCFG)	4	25	50

Product of most likely probabilities: Oil .070 BB, Gas 5.02 TCF, NGL .125 BB, OE 1.031 BBOE

REMARKS

A. No maps or data on trap size and distribution are available. The traps are assumed to be analogous to traps of the maturely explored W. Uzbekistan oil and gas area 100 miles northwest of Afghanistan. Those structures appear to be platform, low-amplitude drapes or fault traps; the trap area making up 8.7 percent of the play area. This platform analogy is extended to the Afghan-Tadzhik subbasin since it is believed that, even though post-salt surface structure is of high amplitude, the pre-salt structure affecting Jurassic strata is faulted-platform in nature. It is assumed that only 35 percent of the traps have been tested owing to depth and the problem of ascertaining pre-salt closures. (.116 x 8.7 x .65 = .66)

B. The overall success rate for the first 50 wildcats is only 8 percent, but only a fraction reached this objective in the central basin. I estimate that deep drilling with more advanced exploration technology will double this rate to 16 percent for this more prospective play. From partial cross sections, the area of fill is estimated to be 30 percent. (.16 x .3 = .048)

C. No data available from Afghanistan, but averaging the data from neighboring Soviet reservoirs, effective thicknesses appear to range from 40 to 400 ft; 200 ft would be about average.

D. The basin is gas prone and the play reservoirs would range from an average depth of 14,000 ft in the Murgab low to 20,000 ft in the Afghan-Tadzhik subbasin. I assume that oil averages 5 percent of the petroleum fill.

E. Porosities from nearest five fields (USSR) are 9 to 20 percent. Oil recovery appears to be low, averaging about 212 BBLS/AF.

F. Thermal gradient about 1.9°F/100 ft; gas recovery at 14,000 ft 727.5 MCF/AF; at 20,000 ft 905.6 MCF/AF. I assume an average of 800 MCFG/AF.

G. Conditions appear favorable for the development of some secondary condensate, except that the oil component may be sparse owing to lack of oil-prone source rock. Excessive depth may have cracked much of the oil. I estimate 25 BNGL/MMCFG.

Table 3

Play Analysis Summary of Undiscovered Petroleum

Basin North Afghanistan No. 1   Country Afghanistan   Play Neocomian drapes   No. 2
Area of basin (mi^2) 48,000   Area of play (MMA) 3.44
Volume of basin (mi^3) 80,000   Play est. orig. reserves 0 BBO 0 TCFG
Estimate original reserves .08 BBO 4.74 TCFG
Tectonic classification of basin: Foredeep and collision zone
Definition and area of play: Limited to platform area covered by an appreciable thickness of Neocomian sediments, i.e. the Murgab low, an area of some 5,368 mi^2 or 3.44 MMA.

	MAJOR GEOLOGICAL/EXPLORATION FACTORS	PROBABILITY DISTRIBUTION 95%	MOST LIKELY	5%
A.	Untested trap area (MMA)	.15	.180	1.00
B.	Percent untested trap area productive (%)	2	7	9
C.	Average effective pay (feet)	25	150	300
D.	Percent oil versus gas in petroleum fill (%)	1	5	15
E.	Oil recovery (BBLS/AF)	50	107	200
F.	Gas recovery (MCF/AF)	500	650	900
G.	NGL recovery (BBLS/MMCFG)	1	4	20

Product of most likely probabilities: Oil .010 BB, Gas 1.167 TCF, NGL .005 BB, OE .210 BBOE

REMARKS

A. No structural maps available, but trap configuration deemed parallel to that at Jurassic level which has been assumed to be analogous to the maturely explored W. Uzbekistan area. This indicates that 8.7 percent of the play area is trap. I estimate the traps have been 40 percent tested. (.087 x .6 x 3.44 = 0.180)

B. To my knowledge, at least seven wildcats were drilled in the Aqchah-Andkhvoy portion of the Murgab low and two gas discoveries were made (as of 1978), giving a success rate of 29 percent. The success rate for the perhaps less prospective part of the play is estimated at 23 percent. The area of fill is unknown. The common average of 30 percent is assumed, giving a productive trap area of 7 percent.

C. Projection of reservoir parameters from the USSR part of the Murgab low indicates a shaling out to the northeast (fig. 9). Maximum reservoirs may be developed along the south and west border of the area; at Khvajeh Gugerdak, for example, the thickness is about 300 ft/90 m). I estimate an average pay thickness over the entire play is about half this, or 150 ft.

D. The basin is gas prone and reservoirs are deep. I estimate 5 percent oil versus gas.

E. Oil recovery would average low because of poor reservoirs. Porosities average about 10 percent.

F. Gas recovery assuming 1.9°F/100 ft thermal gradient and average reservoir depth at 14,000 ft.

G. Assumed same as at Dauletabad in the USSR (4 BNGL/MMCFG).

Table 4

Play Analysis Summary of Undiscovered Petroleum

Basin North Afghanistan No. 1 Country Afghanistan Play Folded Neocomian Reservoirs No. 3
Area of basin (mi^2) 48,000 Area of play (MMA) 9.1
Volume of basin (mi^3) 80,000 Play est. orig. reserves .08 BBO 4.74 TCFG
Estimate original reserves .08 BBO 4.74 TCFG
Tectonic classification of basin: Subsiding platform and collision zone
Definition and area of play: Limited to area within the orogenic zone which has sufficient thickness of Neocomian strata; this would include the Afghan portion of the Afghan-Tadzhik subbasin and the south spurs of Gissar of some 12,700 mi^2 plus the northwestern 1,500 mi^2 corner of the North Afghan basement high.

PROBABILITY DISTRIBUTION

	MAJOR GEOLOGICAL/EXPLORATION FACTORS	95%	MOST LIKELY	5%
A.	Untested trap area (MMA)	.500	.792	.900
B.	Percent untested trap area productive (%)	2	3	5
C.	Average effective pay (feet)	25	150	330
D.	Percent oil versus gas in petroleum fill (%)	1	10	30
E.	Oil recovery (BBLS/AF)	90	118	300
F.	Gas recovery (MCF/AF)	600	743	1,000
G.	NGL recovery (BBLS/MMCFG)	1	4	20

Product of most likely probabilities: Oil .042 BB, Gas 2.383 TCF, NGL .010 BB, OE .449 BBOE

REMARKS

A. By analogy to the Tadzhikistan portion of the Afghan-Tadzhik subbasin, traps in the post-Jurassic rocks make up 11.6 percent of the play area. For the entire USSR portion of the Afghan-Tadzhik subbasin as of 1982, half the traps for all plays were tested. Drilling activity in Afghanistan was less and I estimate that perhaps 75 percent of the relatively deep Neocomian reservoirs are untested. (9.1 x .116 x .75 = .79)

B. The success rate for the Soviet portion of the play as of 1980 was 18.8 percent, but most of this success is believed related to the shallow small Paleogene fields. For the relatively deep Neocomian sandstones, this success rate would be less than half, say 10 percent. Fill is assumed at 30 percent. (.10 x .3 = .03)

C. The Neocomian sands are thick along the north edge of the North Afghan basement high, 285 to 330 ft in the Khvajeh Gugerdak field, but would thin northward away from the high. I assume an average thickness would be around 150 ft.

D. The basin is gas prone and Neocomian reservoirs are deep. Some oil and condensate have been recovered from wells along the north edge of the North Afghan basement high. I estimate 10 percent oil.

E. Porosities appear low, 9 to 14 percent at Hkvajeh-Gugerdak, perhaps averaging 11 percent, giving a yield of 118 BBLS/AF.

F. Reservoirs are deep, perhaps averaging around 13,000 ft, giving a yield of 743 MCF/AF.

G. Assume same as at Dauletabad in the USSR (4 BNGL/MMCFG).

Table 5

Play Analysis Summary of Undiscovered Petroleum

Basin North Afghanistan No. 1 Country Afghanistan Play Folded Paleogene Reservoirs No. 4
Area of basin (mi^2) 48,000 Area of play (MMA) 8.13
Volume of basin (mi^3) 80,000 Play est. orig. reserves 0 BBO 0 TCFG
Estimate original reserves .08 BBO 4.74 TCFG
Tectonic classification of basin: Subsiding platform and collision zone
Definition and area of play: Limited to the orogenic zone where there is sufficient Tertiary cover; this would include the Afghan portion of the Afghan-Tadzhik depression, the south spurs of the Gissar range, a total area of some 12,700 mi^2 or 8.13 MMA.

PROBABILITY DISTRIBUTION

	MAJOR GEOLOGICAL/EXPLORATION FACTORS	95%	MOST LIKELY	5%
A.	Untested trap area (MMA)	.200	.566	.900
B.	Percent untested trap area productive (%)	3	5.6	10
C.	Average effective pay (feet)	25	50	300
D.	Percent oil versus gas in petroleum fill (%)	5	50	70
E.	Oil recovery (BBLS/AF)	100	216	300
F.	Gas recovery (MCF/AF)	700	1,121	1,300
G.	NGL recovery (BBLS/MMCFG)	1	4	10

Product of most likely probabilities: Oil .171 BB, Gas .888 TCF, NGL .004 BB, OE .322 BBOE

REMARKS

A. By analogy to the Tadzhikistan portion of the Afghan-Tadzhik depression, traps in the post-Jurassic rocks make up 11.6 percent of the play area. For the entire USSR portion of the Afghan-Tadzhik depression, half the traps as of 1980 were reportedly tested. I estimate that for the Afghanistan portion, about 60 percent of the traps at Paleogene level remain untested. (8.13 x .116 x .6 = .566)

B. The drilling success rate for the USSR portion of Afghan-Tadzhik depression was 18.8 percent as of 1980. Although a minor amount of this success might be for deeper horizons without success at the shallower Paleogene level, this is assumed to be the average success for the Paleogene play. The fill is assumed to be about 30 percent. (.88 x .3 = .056)

C. No data are available concerning pay, but evident minor productivity of USSR fields suggests minimum reservoir thicknesses; we estimate an average pay of 50 ft.

D. The basin is gas-prone, but oil occurs in shallower zones, and the Paleogene reservoirs of the USSR fields of the Afghan-Tadzhik depression are mainly oil-filled. The untested structures would probably be deeper, however, and we estimate an average oil content of 50 percent.

E. No reservoir data available. I assume 20 percent porosity, 25 percent water saturation, and 25 percent recovery.

F. Assume average depth is 10,000 ft. Thermal gradient is 1.9°F/100 ft.

G. Assumed same as at Dauletabad in the USSR (4 BNGL/MMCFG).

Table 6

Play Analysis Summary of Undiscovered Petroleum

Basin North Afghanistan No. 6 Country Afghanistan Play Western Fold Belt No. 5
Area of basin (mi^2) 48,000 Area of play (MMA) 2.45
Volume of basin (mi^3) 80,000 Play est. orig. reserves 0 BBO 0 TCFG
Estimate original reserves .08 BBO 4.74 TCFG
Tectonic classification of basin: Subsiding platform and collision zone
Definition and area of play: Area of folds south of Badkhyz-Karabil Step and Maymenah high includes Kalarinisk and Kalaimor depressions and adjoining folds. Area of thin section with Neocomian reservoirs and Upper Jurassic evaporite cover rocks missing.

	MAJOR GEOLOGICAL/EXPLORATION FACTORS	PROBABILITY DISTRIBUTION 95%	MOST LIKELY	5%
A.	Untested trap area (MMA)	.05	.142	.900
B.	Percent untested trap area productive (%)	1	3	5
C.	Average effective pay (feet)	25	50	150
D.	Percent oil versus gas in petroleum fill (%)	1	5	25
E.	Oil recovery (BBLS/AF)	100	216	300
F.	Gas recovery (MCF/AF)	600	753	900
G.	NGL recovery (BBLS/MMCFG)	1	4	20

Product of most likely probabilities: Oil .002 BB, Gas .152 TCF, NGL .001 BB, OE .028 BBOE

REMARKS

A. In the absence of any better local analog, the trap concentration in the folds of the Afghan-Tadzhik depression, i.e. 11.6 percent of play area, is assumed for this area. It is assumed that 50 percent of the traps have been tested. (2.45 x .116 x .5 = .142)

B. No success has been reported, but nearby small USSR fields indicate the likely presence of some fields. I estimate 10 percent of traps have hydrocarbon and assume a 30 percent fill. (.10 x .30 = .03)

C. On the basis of the evident small production of the USSR fields, an average total pay of 50 ft is assumed.

D. The basin is gas-prone and nearby fields are gas and condensate fields, estimate only 5 percent oil.

E. No reservoir data available. I assume 20 percent porosity, 25 percent water saturation, 25 percent oil recovery.

F. Assume 6,000-ft depth. Thermal gradient of 1.9°F/100 ft.

G. Gas of this area is assumed to be largely dry, the same as at Dauletabad in the USSR (4 BLNG/MMCFG).

REFERENCES

Boulin, J., 1981, Afghanistan structure, greater India concept and Eastern Tethys evolution: Tectonophysics, v. 72, p. 261-287.

Bratash, V.I., Egupov, S.V., Pechnikov, V.V., and Shelomentsev, A.I., 1970, Geology and oil and gas potential of Northern Afghanistan: Trudy VNIGRI no. 80, 288 p.

Chetverikova, O.P., Viktorova, N.S., and Pentina, T., Yu, 1982, Scales of oil and gas formation in Mesozoic sediments of the Turan platform: Trudy VNIGRI no. 240, p. 138-155 (English summary in Petroleum Geology, v. 20, no. 9, p. 405-410).

Clarke, J.W., 1988, Petroleum geology of the Amu-Dar'ya oil and gas province of Soviet Central Asia: U.S. Geological Survey Open-File Report 88-272.

Escap, 1980, II Summaries of country activities in the appraisal, development, and management of mineral resources, 1976-1978: Proceedings, Sixth Session of Comm. on Natural Resources, Mineral Resources Development Series No. 47, United Nations, New York.

Kingston, John, 1986, Undiscovered petroleum of South Asia: U.S. Geological Survey Open-File Report 86-80, 131 p.

Kravchenko, K.N., and others, 1983, Improvement in calculating the backlog of structures in Tadzhik SSR: Trudy VNIGRI no. 249, p. 120-131 (English summary in Petroleum Geology, v. 22, no. 5, p. 230-232).

Levitskiz, S.I., 1980, Oil and gas potential of zones of deep faults of the Tadzhik Depression: Geologiya i Geokhemiya Goryuchikh Iskopayemykh No. 55, p. 90-104 (English summary in Petroleum Geology, v. 19, no. 2, p. 104-107).

Majeed, A.Q., and Aurah, A.L., 1967, Case history of the Kwaja Gogerdak and Yatim Tagh gas fields of northern Afghanistan: ESCAFE, M.R.D.S. no. 29 (document I and NR/P.R. 3/43).

Makhkamov, R., Mavlyanov, B.N., Niyazov, and Dzhumankulov, M.KH., 1981, Non-anticlinal traps - a source for increasing oil and gas reserves in the Soviet part of the Afghan-Tadzhik Depression: Geologiyz Nefti i Gaza, No. 10, p. 26-29 (English summary in Petroleum Geology, v. 19, no. 10, p. 486-488).

Oil and Gas Journal, 1979, Afghanistan steps up drive for oil production: v. 77, no. 14, p. 64.

Oil and Gas Journal, 1982, Rebels disrupt Soviet plans in Afghanistan: v. 80, no. 37, p. 34.

Roadifer, R., 1975, A probability approach to estimate volumes of undiscovered oil and gas: American Association of Petroleum Geologists Research Symposium, Stanford University, Notes, p. 1-18.

Shroder, J.F., 1983, The U.S.S.R. and Afghanistan mineral resources, *in* International Minerals, a National Prospective, edited by Agnew, A.F., AAAS Selected Symposium 90, p. 115-137.

Sokolov, I.P., and Zelinen, N.A., 1979, New exploration targets in West Uzbekistan, Geologiya Nefti i Gaza, no. 6, p. 15-18 (English Summary in Petroleum Geology, v. 17, no. 6, p. 257-259).