United States Department of the Interior
U. S. Geological Survey

ASSESSMENT OF THE COAL RESOURCES OF THE KYRGYZ REPUBLIC:

COAL CHARACTER AND DISTRIBUTION, GEOLOGY, MINING, AND IMPORTANCE TO THE NATION'S FUTURE

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ОЦЕНКА РЕСУРСОВ КАМЕННОГО УГЛЯ РЕСПУБЛИКИ КЫРГЫЗСТАН:

геология, характеристики угля, добыча, распределение запасов и важность проблемы для страны

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I. EXECUTIVE SUMMARY

This analysis of the coal industry in the newly-independent Kyrgyz Republic (formerly part of the U.S.S.R.) was done by a team composed of geologists, a mining engineer and a coal utilization specialist under sponsorship of the U.S. Agency for International Development. In Kyrgyzstan the members of the team analyzed coal resources and the mining practices in thirteen mines (in six mining regions), visited major thermal and electric stations that use coal, and consulted technical and management people in laboratories, ministries and in state and private mining companies.

This report, available from the U. S. Geological Survey in English and in Russian, contains this executive summary, the large main body of the report, and appendixes. The executive summary first lists the conclusions and suggestions for action and follows with the background and methods of the study and with description of the present situation of the state and private coal industry in Kyrgyzstan.

A. CONCLUSIONS AND SUGGESTIONS FOR ACTION

The preferred future energy budget of the Kyrgyz Republic requires commitment to mining and utilization of the coal resources of the nation. Without domestically-produced coal, future energy budgets of the Republic will depend on imported fuels to satisfy much or most of the energy requirements of Kyrgyzstan.

In the most recently available energy policy planning document (Amanaliyev, 1993), it was expected that coal would satisfy a substantial portion of the Republic's energy budget for the foreseeable future. In 2010, eight million tonnes of coal would be required, and coal and hydrocarbon products would satisfy 57 percent of the total energy demand, with hydroelectricity providing the remainder. Obviously, this scenario may change as a result of the recent drop in total energy supply/demand and the drastic decrease in coal production in recent years. The desirability of satisfying domestic energy requirements with indigenous energy sources will remain.

In order to help the coal industry of Kyrgyzstan satisfy its responsibilities in the future energy budgets of the nation the following suggestions for action are offered:

1.-- **Resume exploration and development of the nation's coal resources.** Coal exploration peaked several decades ago and has been conducted at a very low level of effort in recent years. Both exploration and development activities have apparently been concentrated in past and present mining areas, and as a consequence so are a large portion of the estimated potentially recoverable reserves of the country. Some mining areas reportedly still have considerable mining potential and may be worthy of exploration to evaluate the amount of remaining reserves that might be available for mining. Some known coal areas that might be important for future mining have been inadequately explored and require exploration and development studies to determine their resource potential. In some known coal regions of the country, coal mining has apparently never been seriously considered and the quantity, quality and distribution of the coal resources is poorly known. Coals are not presently selected for low sulfur content, and increased environmental concerns may require this. Informed planning for the nation's energy future requires more information than is presently available.

2.-- **Evaluate the amount of coal available and economically recoverable from a market-economy viewpoint in the coal areas of the country.** Economic factors previously used in the evaluation of Kyrgyzstan's potentially recoverable reserves are no longer valid. Up-to-date classification from a free market-economy standpoint is needed. The studies should provide basic data about the coal resources that are recoverable at a cost that the economy of Kyrgyzstan can accept. Studies of this type are required before investment of time, energy and capital in elements of a coal industry can be further justified.

3.-- **Gather and organize the presently available information that can affect the future coal industry of Kyrgyzstan.** As a minimum, the location of such information should be recorded. Ideally, the information should be gathered and organized so duplication might be avoided with considerable savings in time and money in the future.

4.-- **Encourage mines with depleted reserves and worn out equipment to produce as much coal as possible for as long as possible with a minimum of capital investment until safety and efficiency require closure.** Support changes in mining methods that may extend the life of such mines.

5.-- **Determine which mines and mining areas can increase coal production in a short time. Provide solid, market-economy-based data on their coal availability and recoverability.** Establish the engineering and economic parameters for successful operation of such short-term elements of the future coal mining industry. Seek capital investment for development of such areas.

6.-- **Increase production to satisfy local demand in all parts of the country that contain economically recoverable coal by assisting the Private Enterprises Mining Program.** The Private Enterprises Mining Program is the successor to the Small Enterprises Mining Program that was initiated a few years ago to satisfy critical domestic coal needs. This program needs assistance and training in resource understanding, engineering technology, marketing concepts and techniques as used in a free-market-economy. The 15 licensed small private mines in the program were responsible for more than one-eighth of the total coal production of the Republic in 1995. The small private miners should be encouraged and assisted in their efforts to become responsible members of a free-enterprise, market-economy system.

7.-- **Research and test the feasibility of briquetting as a solution to the problem of coal fines.** Because of the friability of the coals of Kyrgyzstan a large proportion of the coal produced is of fine-size (13mm or less). At the present time, only coarse coal has a ready market. Aggregation of the otherwise useless fine-sized coal into a coarser product is worthy of investigation. Demonstration of the technical feasibility of making usable briquettes from the variety of coal ranks, grades, types and available binder materials is required. Of equal importance and need is informed evaluation of the economics of production and the size, location and financial capabilities of potential markets for the briquettes.

8.-- **Investigate the possibility of increasing coal production at the Dzhergalan mine in the Issyk Kul coal region to supply coal to the Chu Valley Region.** The present dependency of northern Kyrgyzstan on imported coal might be at least partially alleviated by supplying better-quality domestic coal to the district heating and electricity-generating plants at Bishkek and Kara Balta.

9.-- **Increase the routine maintenance of existing roads used to haul coal and extend the railroad system of the Republic.** The road and railroad network that was inherited from the former Union has declined severely. The existing rail network was not designed to serve the economy within the present national borders. An expanded railroad transportation system is needed to help solve the problem of transporting domestically-produced coal for use internally, and perhaps for export.

10.--**Schedule periodic, preferably annual, reviews of the coal industry of the Kyrgyz Republic to provide a continuing update and analysis of the progress of coal exploration, mining, marketing and utilization.** Reviews by country-knowledgeable specialists would be a source of unbiased, reliable information for those developing the coal industry of the Republic, for those contemplating investing in the industry, and for those interested in assisting and supporting the coal industry as a vital part of a sound market-oriented economy.

More than 50 percent of the energy resources of Kyrgyzstan are embodied in its coal resources--hydropower constitutes the bulk of the remainder. A significant part of the energy to be consumed by Kyrgyzstan in both the short-and long-term future is projected to be provided by coal. If coal is not produced domestically it must be imported, as are most oil and gas, with the attendant international exchange and dependency problems.

Inherent in the previous suggestions is the requirement for training of various kinds. Training and practical experience are needed in mine management, mine planning and design techniques, financial systems and marketing. The small private coal-mining enterprises need assistance specifically in understanding geologic and mining engineering factors, mining technology, development and maintenance of markets, and training in the basic economics, legal requirements and societal responsibilities of private enterprises.

B. BACKGROUND

Assessment of the coal resource situation in Kyrgyzstan was identified by representatives of the United States Agency for International Development and officials of the Kyrgyz Republic (Kyrgyzstan) as a useful area for collaboration. The study was conducted by the United States Geological Survey and consultants provided by IDEA , Inc. of Washington, D.C. with the assistance of counterpart personnel of agencies of the Government of Kyrgyzstan, particularly the Ministry of Industry, Material Resources, and Trade, the Ministry of Geology and Mineral Resources and the Institute of Geology of the Academy of Sciences.

The rugged, mountainous country of Kyrgyzstan contains about one-half of the coal resources of the Central Asian Republics (exclusive of Kazakstan). The geological coal resources of the country are estimated to total about 31,000 million tonnes. However, the amount and distribution of coal resource information allows less than eight percent of the total to be categorized as technically recoverable reserves and the amount that is economically recoverable is unknown.

Coal is present in eight regions in Kyrgyzstan in at least 60 different, named localities. Historically, the coal industry first developed around the periphery of the Fergana Valley of Kyrgyzstan, Uzbekistan, and Tadjikistan where the industry had access to the transportation facilities that served the valley and consequently could serve coal markets in those republics and in Kazakstan. Eventually, two mining areas were opened in the northeastern part of Kyrgyzstan to satisfy local demand there.

During the Second World War, exploration of the coal resources of Kyrgyzstan received emphasis that continued for two decades. Preliminary exploration of the coal resources of the Uzgen basin established the presence of high-quality coals with a range of ranks from subbituminous-A through anthracite, but development for extraction has not followed to the extent possible. Only in recent years have two mining areas discovered in the early '50s been operated in the coal-rich Kavak region of central Kyrgyzstan, but the few roads in the region limit extraction and transportation capabilities. The coal resources of south-central Kyrgyzstan have not been explored beyond reconnaissance stage efforts and only two small mines are present. Exploration and development efforts in Kyrgyzstan have been local and on a reduced scale since the end of the 1960's. The main coal deposits and reserves are summarized already in Gavrilin and Kuznetsov, 1968.

C. THIS STUDY

A summary of this assignment is as follows: (a) Gather, interpret, and summarize available information on the coal resources of Kyrgyzstan; (b) Complement the existing data through field observations and cooperative studies; (c) Identify needs and opportunities for expansion of the resource database; and (d) Identify and recommend activities to assist and support short and long-term resource expansion, recovery, marketing and utilization.

A team of four geologists, a coal mining engineer and a coal utilization specialist worked in Kyrgyzstan during October and part of November, 1994. They sampled coals and analyzed engineering practices at thirteen mines (in six of eight coal regions of the country), visited four major thermal and electric stations that use coal, and consulted with technical and management people in laboratories, ministries and other components of the coal industry. Three members of the team returned to Kyrgyzstan in May, 1996 to discuss the findings presented in a preliminary report with counterparts and update the contained information. This report, with its appendixes, contains the information and recommendations from the field work and also analytical data and other results of work conducted in the U.S.

The coals of Kyrgyzstan are widely scattered in a geologically complex terrain; they are all of Jurassic age. They are probably similar in general to Jurassic coals in other parts of Central Asia, in China, and in southern Russia. The largest area of coal-bearing formations that remains intact is in the Uzgen Basin in the East Fergana coal area, other known Jurassic rocks are fragmented and scattered.

The reserves and resources of coal have been appraised according to Soviet systems. Commercial (balance) reserves are estimated (in million tonnes) as about 1250 million tonnes brown coal and 1000 million tonnes bituminous coal and some anthracite. The mining method indicated for these reserves is 300 million tonnes by opencast and 1950 million tonnes by underground mining. Most exploration at a detail needed to define reserves has been confined to sites close to existing mines, with the consequence that reserves are less than ten percent of the estimated geological coal resource of about 31,000 million tonnes.

The coals classed as brown coal B3 are subbituminous in U.S. terms and the long flame coals are mostly high-volatile C bituminous in U.S. terms. The heat yield of produced coals is 20 to 25 MJ/kg (8500-11000 Btu/lb) except where excess rock contaminates the product, and some coals with higher heat could be produced. Over many years most mines have produced coal with 10-20% ash. The petrographic composition ranges to higher inertinite content than in most U.S. and European coals, and associated with this is a generally lower hydrogen content. The samples collected by the team included three with sulfur greater than 2%, but older recorded data show that values over 2% are the exception. Excluding the one high rank coal sampled (low-volatile bituminous), coals sampled by the team are representative of most coals reported produced in Kyrgyzstan and have 8 to 28% bed moisture, 33-51% volatile matter (daf), 71-83% elemental carbon (daf) and 0.3-0.8% vitrinite reflectance. The USGS analyses supported older Soviet work in most respects, but lower hydrogen and lower sulfur were reported in some older work -- possibly a result of selective sampling, not analytical errors.

The USGS trace element data show little that is remarkable in view of typical world-wide values and show no likely problems for coal utilization. Elements like chlorine, selenium and mercury, which may be of concern in some forms of utilization, are notably lower in Kyrgyz coals than in many coals of the world.

D. THE COAL INDUSTRY AT PRESENT AND IN THE NEAR FUTURE

As recently as 1990 the annual coal production of Kyrgyzstan was about 4 million tonnes, but in the last few years coal production has drastically decreased and the production in 1995 was only about 455 thousand tonnes. Reasons for the decrease are given as depletion of reserves in old mine areas, obsolete and worn-out equipment, shortages of fuel, uninspired and unpaid miners, loss of experienced management and technical personnel by emigration, loss of markets by intra- and extra-national decisions, poor transportation infrastructure, and other problems inherent in transition from a centrally-planned economy to a market-based national economy.

The coal industry inherited with independence is in the process of restructuring itself. The previously monolithic government coal company, KYRGYZKOMUR, is in the process of spawning thirteen or more subsidiaries. As the subsidiaries are created, they operate under the overview of newly-created KYRGYZKOMURHOLDING. The subsidiaries, called State Stock Societies, presumably will have more opportunity for individual success or failure than was previously possible. Coordination of effort among the State Stock Societies is apparently the responsibility of KYRGYZKOMURHOLDING; the amount of direction is unclear.

Tenders were recently accepted from the German firm Rheinbraun Engineering und Wasser in response to a request for tenders regarding a coal industry support program for KYRGYZKOMURHOLDING. The start date is about October, 1996. The program will be sponsored by EUROPEAN UNION/TECHNICAL ASSISTANCE CONFEDERATED INDEPENDENT STATES (EU/TACIS). As described in the request for tenders, the program comprises training of one-year duration with emphasis on financial systems, mine management, marketing, and mine planning and design techniques. As much as fifteen percent of the total program funding may provide equipment, perhaps mostly computers. Whether any of the training will be available to private mining enterprises is unknown.

An earlier change in the structure of the coal mining industry in the Republic was the initiation of the Small Enterprises Mining Program with its inherent possibilities of true privatization. Recently the Small Enterprises Mining Program changed to the <u>Private</u> Enterprises Mining Program. The change is from a program initiated as a humanitarian response to energy shortages in parts of the nation, to a program emphasizing the acceptance of production responsibilities by privately-funded and operated enterprises. Private enterprises supplied about 1/8th of the coal produced in the Republic in 1995. The transition to market-responsive, privately-owned, free-enterprise small coal mining companies would be assisted by advice and training in technology, marketing, and small-business operations.

II. INTRODUCTION

A. BACKGROUND

In August of 1992, as a result of discussions between a United States Agency for International Development (USAID) Energy Mission and officials of the Kyrgyz Republic (Kyrgyzstan), a memorandum was signed in which useful areas for collaboration between USAID and the Government of the Kyrgyz Republic were identified for further consideration. One of the identified areas was an assessment of the coal resource situation in Kyrgyzstan. The results of such an assessment could become a key factor in considerations of the future of the coal industry in energy policy and planning for the nation.

A reconnaissance visit to Kyrgyzstan in February, 1994, identified counterparts for the collaborative effort and technical expertise needed in the USAID-sponsored assessment team, and resulted in a mutually acceptable activity implementation plan. The team formed for assessment of the coal situation in Kyrgyzstan formally initiated operations on October 2, 1994. The team comprised four members of the U.S. Geological Survey (USGS) and two consultants under contract to IDEA, Inc. of Washington, D.C. The USGS team members operate under provisions of Participating Agency Service Agreement (PASA) No.CCN-0002-P-ID-3097-00 between the USAID and the Department of the Interior-United States Geological Survey.

The objectives and scope of study for the USGS team members are outlined in Annex 4 of the PASA, and in a scope of work statement dated September 20, 1994, are as follows: (a) to gather, interpret, and summarize available information on the country's coal resources; (b) to complement the existing data through field observations and cooperative studies; (c) to identify needs and opportunities for expansion of the resource database; and (d) to identify and recommend activities needed for assistance and support of short and long-term resource expansion, recovery, marketing and utilization.

The USGS personnel on the assessment team collaborated with the coal mining consultant and the coal utilization specialist supplied by USAID who worked simultaneously on tasks relevant to the overall evaluation of the current and prospective future of the coal mining industry of Kyrgyzstan. The work of the consultants was integrated in the common team effort.

B. SUMMARY OF FIELD ACTIVITIES

During the period October 7 through November 12, 1994, the assessment team was in Kyrgyzstan and Kazakstan. Much of the time was spent in discussions with counterparts and others, gathering information from a wide range of sources, and organizing the data. Part of the time was spent in field site visits to thirteen coal deposits in six of the eight regions where coal has been reported in Kyrgyzstan. In addition, four facilities using coal for electric power generation and production of steam for heat were also visited, and three coal analytical laboratories were visited.

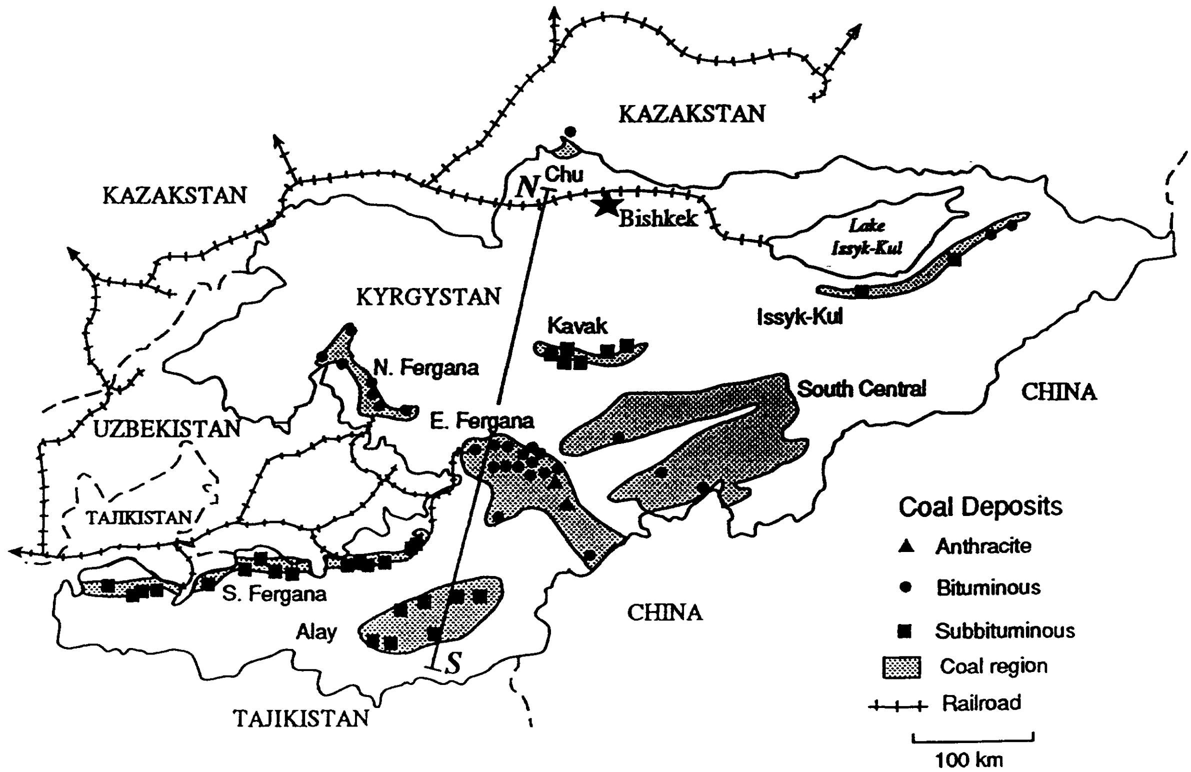

Figure 1. The coal regions of Kyrgyzstan and railroads of the FSU (dotted lines) and borders dividing other countries adjacent to Kyrgyzstan (dashed lines). Individual mines or prospected deposits are denoted by symbols that indicate the coal rank; these symbols are from a manuscript compilation by Solpuyev and co-workers, 1994. The "bituminous" designation for coals in N. Fergana includes coals ranked as subbituminous by the USGS. To the left on the map, the borders between Kyrgyzstan and Uzbekistan or Tajikistan are complex along the edges of the Fergana Valley. Only the edges and mountains around the Valley are in Kyrgyzstan. The line N-S shows the position of the vertical terrain and geological section of figure 4.

Attached are maps (fig. 1 and 2) showing the eight coal regions of Kyrgyzstan and the field localities visited by personnel of the team. Before the field studies, the team had learned of only about 45 localities; now we know of 60 localities. Some of the additional 15 localities are subdivisions of previously identified areas, but many were previously unreported in literature available outside of Kyrgyzstan.

English and Russian versions of a draft final report were transmitted for comment and suggestions in April and July, 1995, respectively. Three team members returned to Kyrgyzstan in May, 1996, to discuss the final report with counterparts and USAID personnel, and to update information as needed.

C. KYRGYZSTAN -- THE LAND AND PEOPLE

Most of Kyrgyzstan is ruggedly mountainous and only about seven percent of the country is classified as arable land. Much of the remainder is marginally usable for grazing of sheep and goats. Most of the country is at altitudes between 500 and 3,000 meters above sea level and more than one-third of the country is between 3,000 and 4,000 meters above sea level. Mountain peaks reach altitudes of more than 7,000 meters and more than 8,000 square kilometers are covered by glaciers. The climate ranges from subtropical to polar but is largely arid temperate continental and features warm summers and cold winters. Much of the population of about 4.5 million lives in valleys and foothills at lower altitudes. Most of the country at higher altitudes is very sparsely populated except during the summer grazing season.

Kyrgyzstan has a total area of about 198,500 square kilometers, comparable to the state of South Dakota in the U.S.A., and is divided into seven oblasttar for administrative purposes (fig.3). Railroads total about 370 kilometers in length and highways - paved, graveled, and unpaved - total about 30,300 kilometers.

D. COAL REGIONS AND RESOURCES OF KYRGYZSTAN

The bulk of the existing coal industry is concentrated in the southwestern part of the country, peripheral to the Fergana Valley. Here, the coal industry has access to many highways and railroads (fig.1). Most of the Fergana Valley and the highway and railroad systems therein are in Uzbekistan and Tadjikistan. Use of the transportation net in the Fergana Valley has become increasingly difficult for Kyrgyzstan since independence. The existing coal industry in the central and northeastern parts of Kyrgyzstan is dependent on roads for transport of coal to markets. Recent proposals to build a railroad connecting the southwestern and northern parts of Kyrgyzstan deserve serious consideration.

The coal of Kyrgyzstan is mostly of good quality, but only of medium rank (and medium heating value) -- that is, subbituminous and high-volatile bituminous rank. Coals of higher rank,

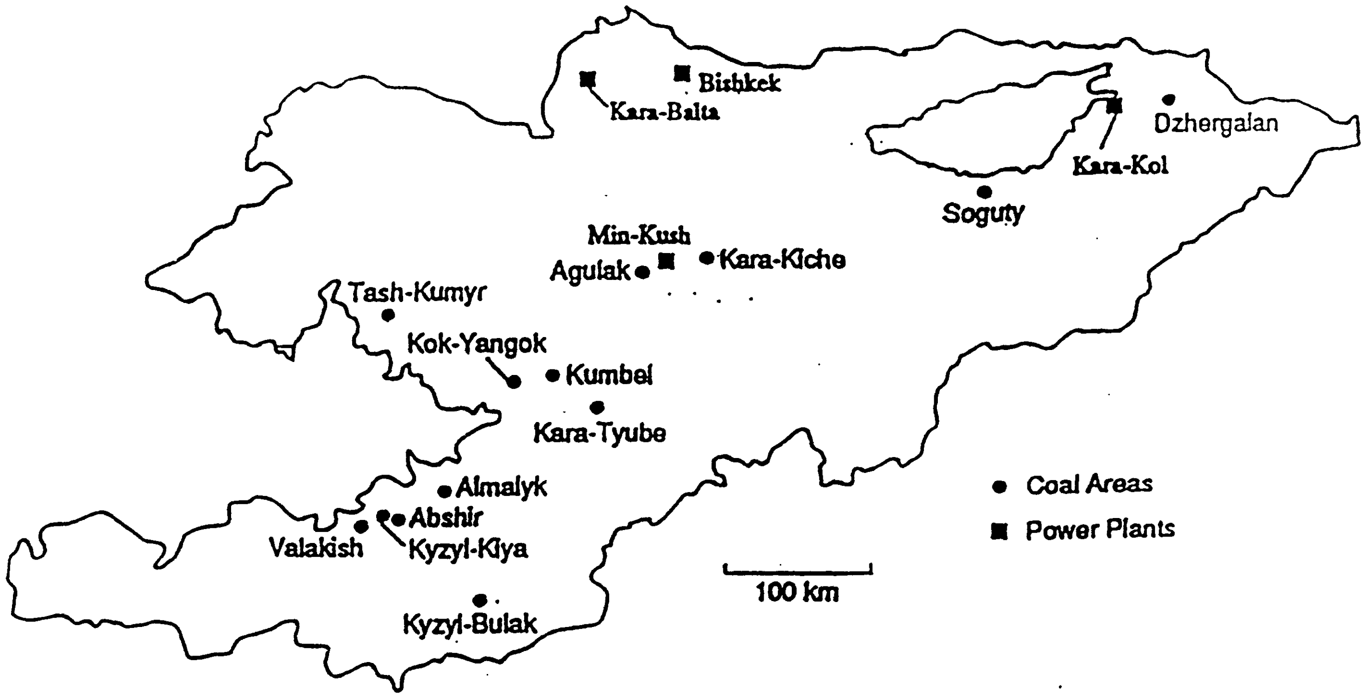

Figure 2. Kyrgyzstan, showing the coal areas and power plants visited by the assessment team in Kyrgyzstan.

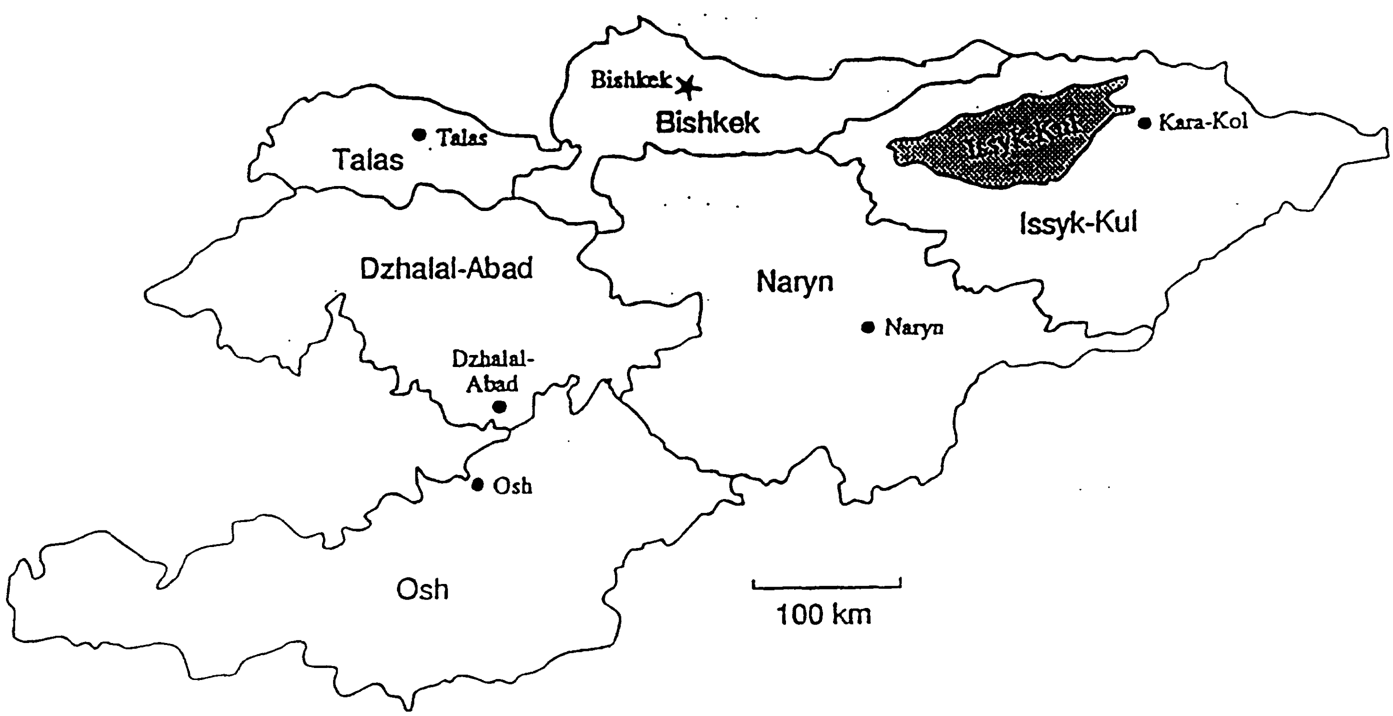

Figure 3. Kyrgyzstan, showing the six political subdivisions (oblasts) with their principal cities. Issyk-Kul is a large land-locked lake.

some with coking qualities, are present in one region. Many deposits of coal are known but undeveloped because the valleys and mountains of Kyrgyzstan are physiographically and geologically complex, transportation infrastructure is poorly developed, and population is sparse in many areas. In this report we will group the mines and other occurrences in the following regions (fig.1):

1. Issyk-Kul region in the northeastern part of the country.
2. Kavak region in the center.
3. North Fergana region in the western part.
4. South Fergana region in the southwestern part.
5. East Fergana (Uzgen Basin) region in the southern part.
6. The Alay region (including the mountains north and south of it) in the southwestern part.
7. South Central region, the coal deposits isolated east of the Fergana Range in the south central part of the Republic.
8. The Chu region (near the Kazakstan border north of Bishkek).

Shallow excavations for local use have yielded coal at several localities in the South Central region and two small mines are operating. The Chu region is unexplored.

The overall resources (geological reserves) of coal in Kyrgyzstan have been reported as about 31,000 million tonnes. Of vastly more importance is the amount economically recoverable in the next few years and during the next decade or two, detailed later in this report. In some of the reported localities the coal resources are known and adequately explored and large quantities of coal await decisions necessary for recovery. In other parts of the republic, particularly in previously remote areas, the coal resources are inadequately understood or largely unexplored. The resource and reserve inventory of Kyrgyzstan is at best incomplete, and for some purposes, such as short-term local and long-range national planning, it may be inadequate.

E. OTHER FOSSIL FUELS

In addition to coal, the Kyrgyz Republic has limited known resources of conventional oil and associated gas, natural gas , and unevaluated potential resources of coalbed methane.

Prior to dissolution of the USSR, oil and gas exploration of the Fergana basin of Uzbekistan, Tadjikistan and Kyrgyzstan resulted in finding more than fifty fields, most of which are in the margins of the Fergana basin. A study of the oil and gas resources of the whole Fergana basin, published by the Energy Information Administration (1995) states that probably within Kyrgyzstan are 14 of the 53 discovered oil and gas fields (26 percent), about 16 percent of the ultimate oil recovery from discovered fields, about 9 percent of ultimate associated-dissolved gas from discovered fields, and about 44 percent of ultimate non-associated gas from discovered fields. Bazarbaev and others (1993), stated that the oil and gas industry of the nation was producing from 13 fields with "industrial " reserves of about 102 million barrels of oil (14.6 x 10^6 tonnes) and

172,000 million cubic feet of gas (4.9 x 10^9 m^3). Operating wells totaled 438, with an average production of 6.3 barrels of oil per day. They further stated that four of the main fields are in the last stage of development, with decreasing production, and that another five fields are almost completely developed and that production is decreasing there also.

Ulmishek and Masters (1993) estimated that the total undiscovered oil resources of the Fergana basin were about 3,000 million barrels, the total undiscovered natural gas resources of the basin were about 3 trillion cubic feet, and that as much as 20 percent of the undiscovered oil and gas resources were in Kyrgyzstan. No estimates for undiscovered resources in other parts of Kyrgyzstan are available. Ulmishek and Masters (1993) recognized two other basins in Kyrgyzstan that might be petroliferous and Bazarbaev and others (1993) point out that there are more than 10 intermontane basins in the Republic with varying prospects for oil and gas. The latter further state that "...they have all ...been extremely poorly studied by oil and gas prospecting operations, and in some of them no such work at all has been carried out."

To the team's knowledge, no exploration for coalbed methane resources has been conducted in Kyrgyzstan. There may be coals of appropriate rank and depth present in the Republic but the presence and amount of gas available for recovery from the coal of the Kyrgyz Republic can only be determined by further specific studies.

F. ACKNOWLEDGEMENTS

An assessment necessarily requires gathering information from a wide range of available sources and receiving fact, opinion, and advice from a wondrously-assorted spectrum of groups and individuals. It is impossible to here record individual thanks to all who have helped us, but we do wish to express a sincere collective thanks to the people of Kyrgyzstan. Their hospitality, knowledge, helpfulness and good humor are unmatched.

We especially must thank Charles Bliss and Rolf Manfred of IDEA Inc./USAID for technical management support, and Paul Hearn, Lisa Martin and Robert Milici of USGS for their guidance and help. Most particularly, we thank K. M. Mukambetov, D. K. Kamchybekov. N. T. Kozhomatov, M. M. Khudoyarov and A. P. Pakhridinov of the Ministry of Industry, Material Resources and Trade. The enthusiastic and knowledgeable assistance of T. D. Sadabaev, G. T. Izyumov and I. Bekishev, of KYRGYZKOMURHOLDING, was very helpful. In addition we thank K. Kakitaev, T. S. Solpuyev and T. Kydyrbaev of the Ministry of Geology and Mineral Resources, and Dr. Apas Bakirov of the Institute of Geology of the Academy of Sciences. Without the cooperation, participation and patience of these gentlemen this assessment would not be possible.

III. COAL IN KYRGYZSTAN

A. GEOLOGIC SETTING

Coal in Kyrgyzstan is of Jurassic age. The coal is younger than the main bituminous coals of Europe, eastern North America, South America, Australia and India. The Kyrgyz coals are, however, older than the low rank coals of western North America. Significant coals of about the same age as those in Kyrgyzstan are present in other Central Asia countries, China, and Russia.

In central Asia the rocks of Jurassic age are overlain unconformably by a variety of rock types ranging from marine Late Cretaceous sedimentary rocks to non-marine thick wedges of fan-type coarse clastics shed by the uplifted mountains being formed during the ongoing Alpine Orogeny. The net effect of Late Cretaceous, Tertiary, and Quaternary geologic history has been concealment of the Jurassic coal-bearing rocks, though exhumation by recent erosion is presently occurring.

Kyrgyzstan and adjoining parts of Central Asia have a very complex geologic history, and much of that history is preserved in the rocks comprising the country. Bakirov and Burtman (1984) recognize four megastages in the geological history of the area. Each megastage is either geosynclinal- orogenic or platform-orogenic in character. From the standpoint of coal geology, only the history of the last megastage, the Mesozoic-Cenozoic platform-orogenic megastage, directly affects the presence and distribution of coal-bearing rocks in the country.

The coal-bearing rocks of Kyrgyzstan are of continental origin and were deposited north of the Tethyan Sea that formerly occupied a large area in central and southern Asia. At least four transgressive-regressive cycles of the seas occurred between Late Triassic age and Late Jurassic age in southwestern and southern Asia (Poliansky, 1980). As much as 6,000 meters of Late Triassic and Jurassic rocks of both continental and marine origin were deposited in localized sedimentary basins on the periphery of the Tethyan Sea. The Jurassic rocks that are preserved in Kyrgyzstan were possibly deposited during the middle two of the above-mentioned cycles. Most occurrences of the Jurassic rocks in the country seem to be tectonically separated remnants of formerly more extensive bodies of Jurassic rocks (fig.4).

The Jurassic rocks of the Uzgen Basin are one of the largest occurrences of Jurassic sedimentary rocks exposed in central Asia. Solpuyev and Bakirov (oral communication, 1994) state that the Jurassic rocks are thinner and mostly of continental origin in the northern part of the Basin where coals occur, and are increasingly thicker and more marine in origin in the southern part of the Basin. Faulting, folding and erosion, all mostly related to the latest cycle of mountain building, the Alpine Orogeny, have locally displaced or removed segments of the Jurassic rocks in the Basin. The rank, type, and quality of the coals in the Basin reflect their depositional history and subsequent geologic events in the area.

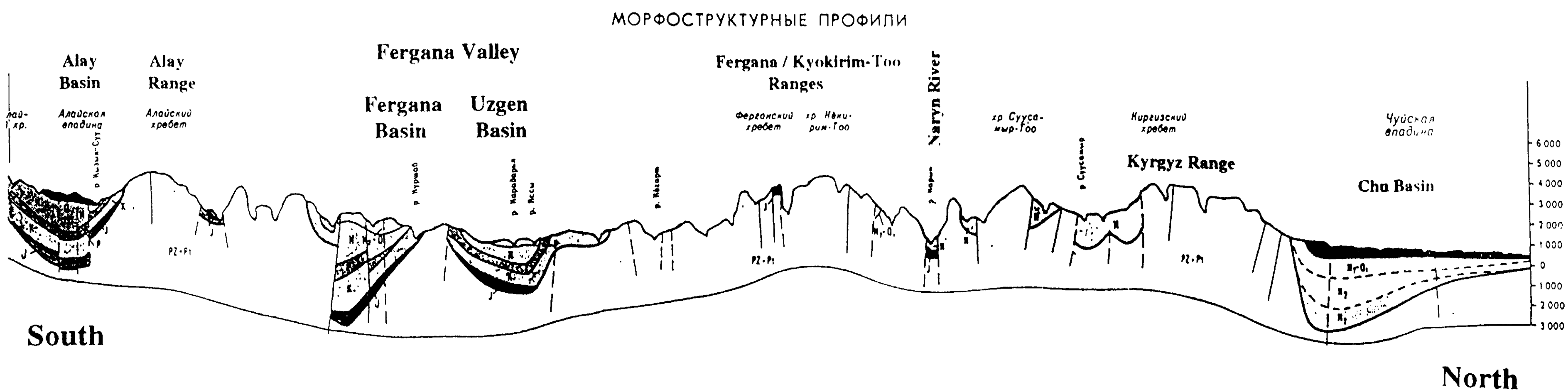

Figure 4. Simplified vertical section of sedimentary basins and terrain south-to-north across Kyrgyzstan, viewed from the east at the eastern end of the Fergana Valley, center left, and near Bishkek, at the right (See line on figure 1). Paleozoic and older rocks (mostly metamorphic and igneous basement) are unshaded. J = Jurassic (coal bearing), K = Cretaceous, P = Paleogene, N = Neogene, Q = Quaternary. From Adyshev, and others, 1987. Vertical exaggeration 6:1.

B. COAL REGIONS AND AREAS

1. Alay Coal Region

The Alay coal region comprises a west-trending, discontinuous series of subbituminous coal deposits just north of the Tadjikistan border in southwestern Kyrgyzstan (fig.1). The area extends in the Kyzyl Suu River valley near the border with Tadjikistan. There are seven named coal localities in the region and the resource potential of the region is poorly understood because of a lack of exploration. Most of the known coal localities are in the foothills of the Alay Range and access for exploration may be difficult because of lack of roads. Two small surface coal mines in the Kyzyl-Bulak area are presently in operation and another nearby in the Norus-Kul area recently started operations (fig.2).

2. South Fergana Coal Region

Coal has been mined in the South Fergana coal region since at least 1866. The region extends along the south side of the Fergana Valley from the southwestern end of Kyrgyzstan to near the city of Osh. Fifteen named coal deposits are known in the region (fig.1). Many of them have been or are being mined and some have been only partially explored. All of the coals in the region are of brown coal rank, perhaps largely of subbituminous B rank in American classification. Most of the deposits are of relatively small size because the Jurassic-age coal-bearing rocks are preserved in folded and faulted segments of the southern edge of the Fergana basin.

A major portion of the coal formerly produced in the region was destined for industrial and boiler fuel and domestic use in adjoining parts of Tadjikistan and Uzbekistan. That market has at least partially disappeared because of new national / economic borders that dissect natural regions that were formerly unified in the USSR, but various types of barter arrangements exist.

3. East Fergana Coal Region (Uzgen Basin)

The East Fergana coal region contains seventeen named coal localities in a belt of Jurassic rocks that extends from near Dzhalal Abad southeast to the border with China (fig.1). The region contains the largest block of coal-bearing Jurassic rocks in the Republic and the rocks are all believed to have been deposited in the same depositional basin, the Uzgen Basin (Kashirin, Ibragimov, and Karabalayev, 1975). Folds and faults are common and some parts of the block are now isolated from the main mass. The Jurassic rocks are thinnest in the northwestern part of the region and there are more coal beds in that area. The Jurassic rocks are as much as 5,000m thick in the southern part of the region but there are fewer coal beds. All of the coal-bearing rocks of Jurassic age are preserved on the southwest flank of the Fergana Range. The Fergana Range is the site of the Talas-Fergana fault, a striking structural feature of Central Asia with lateral displacement of as much as 180 km with movement continuing at the present time. A member of the Institute of Geology called it their San Andreas fault.

The coal in the region ranges in rank from bituminous to anthracite. Some of the coal is reported to have coking characteristics but there is no market demand for this coal at present. Some places in the region have long mining histories but many areas are poorly explored and undeveloped. Several localities in the region are presently producing coal from mines opened as part of the Private Enterprises Mining Program and some other areas might be suitable with more exploration and access.

4. North Fergana Coal Region

The North Fergana coal region comprises a northwest-trending belt of Jurassic rocks that extends from the small village of Avletim on the north to the Kara Unkyur River on the southeast. Coal of subbituminous-A and -B rank (long-flame rank) is present at seven different localities in the region. Although Dzhal-Abad is the main city of the region, Osh is the major city servicing the coal industry, and the headquarters of both the KYRGYZKOMUR and the Association of Small (Private) Enterprises are located there. Direct access to the region is by good roads that cross Uzbekistan. The coal deposits of the North Fergana Region were selected for early development in energy budget planning for the central Asia region of the former Soviet Union because of their location relative to transportation infrastructure and to areas of energy need. The mining complex headquartered at Tash-Kumyr includes The Kara Tut and Tegenek mines. In this general area the coal-bearing sequence contains several seams that are mined in different parts of the area. In some localities, such as the Severnay underground mine, two or more coal beds contained major reserves.

Most of the coal localities are located in the foothills of the Fergana Range near or in the valley of the Naryn River. Near here the Naryn is joined by other streams and, named the Syr Darya, extends northwest as the major source of water for the irrigated farming areas of Uzbekistan and Kazakstan and eventually to the dwindling Aral Sea.

In the past, the North Fergana Region produced much of the coal that was transported by railroad to destinations in Kyrgyzstan, Uzbekistan, and Kazakstan. For a variety of reasons these markets no longer exist or are only partially accessible.

5. South-Central Coal Region

Coal is known to be present in three deposits in the South Central coal region. The known deposits are all in small exposures of the coal-bearing rocks of Jurassic age. The rocks of Jurassic age are only exposed at a few places in the region but could from a geological perspective be present underneath younger rocks at other places as well. Exploration of all types is needed to allow even a preliminary understanding of the coal resource potential of the region. The rank of weathered samples reported from two sites is near the subbituminous / bituminous boundary.

The lightly-inhabited region is poorly connected by roads to the remainder of Kyrgyzstan. A ready market exists there for coal hauled into the region from the Kavak coal basin. A new mine in the Turuk area was inaugurated by the President of the Republic in December, 1995. Reportedly, attempts are underway to open a mine in the Aksay area. The region is suffering an energy shortage and the team received reports from diverse sources that residents were starting to cut the existing trees for winter fuel. Exploration of more of the known coal deposits to assist Private Enterprises mining should be undertaken as soon as possible.

The very limited exploration done to date provides small basis for resource evaluation in the area, but the Aksay area is estimated to contain as much as 121 thousand tonnes of coal, all in the inferred category (but not approved by a central commission), and the Turuk area is predicted (P3) to contain about 5 and a half million tonnes of coal, of which 62 thousand tonnes are in the balance category (but not officially approved) and the rest, 5.4 million tonnes, in the speculative category. There are no available resource estimates for the Turugart area but thin lenticular bodies of poor quality coal are reported at several places in an area 1km by 17km. Coal is reportedly present at least one more place in the region but no information is available.

The region contains the upper part of the Naryn River, the site of numerous hydropower development proposals. Supplemental sources of energy in the region will be needed during development if it proceeds. Whether coal can provide that other energy must be determined by exploration.

6. Kavak Coal Region

The Kavak coal region is located in the central part of Kyrgyzstan 130 km south of Bishkek (fig. 1, 2). The six named coal localities in the region are in the foothills of several discontinuous mountain ranges that occupy much of the central part of Kyrgyzstan. In particular, most of the region lies between the Dzhumgoltau on the north and the Moldotau on the south. To reach the Kavak region from Bishkek one must travel east to Balykchy near the western end of Lake Issyk Kul and then proceed southwest an equal distance to the region. Alternatively, the Kavak region can be reached over a precipitous road over the Kyrgyz Range south of Kara Balta, which is west of Bishkek.

The coal occurs within a discontinuous, west-trending belt of Jurassic rocks in the general vicinity of Min Kush (fig. 2). Two operating coal mines are located in the Kavak region, Kara-Kiche and Agulak. The two mines are separated areally by about 42 km, but by road the distance is about 90 km. Both mines are administrated from Agulak. In addition to these two mines, at least four undeveloped coal occurrences are reported to be present in the area. Development and recovery of coal in the region has largely taken place in the past few years but geologic understanding of the area is well advanced because the Jurassic rocks that contain the coal also contain uranium that was intensively mined a few decades ago. Recently, a private enterprise mine has been developed in the Kara-Kiche area. The coals are subbituminous-B in rank (B3 rank).

Total resource estimates for the region are about 812 million tonnes. This is probably a conservative figure that would be increased if exploration was resumed to increase the recoverable reserves of the region.

7. Issyk-Kul Coal Region

A narrow belt of Jurassic sedimentary rocks, including coals, extends nearly the entire length of Issyk-Kul' (lake) along its south shore and an equal distance farther east past the border into Kazakstan nearly to China (fig. 1). In parts of this belt of rock many coal beds have been reported, but only two sites with adequate thickness, extent, and access are known to date. Soguty, at the town of Kadzhi-Say on the south shore of Issyk Kul, is subbituminous coal, mined both for energy and, in the 1940's, for uranium from ash concentrates; Soguty closed in 1995-96. Dzhergalan, east near the Kazakstan border, is mined for high-volatile bituminous coal (long-flame coal).

Both of the mines formerly supplied coal to the district heat plant at Kara Kol (Przhevalsk) at the east end of Issyk Kul. The mine at Soguty is in the process of deactivation because the recoverable reserves are reportedly depleted. The present mine at Dzhergalan still has minable reserves to recover and in addition there is an estimated 12 million tonnes of proven and probable reserves nearby that could be mined if new inclined shafts were built.

8. Chu Coal Region

The Chu region is located in the northernmost part of Kyrgyzstan about 40 km northwest of Bishkek (fig. 1). Chu is the name of the westward-flowing river that forms a portion of the country's border with Kazakstan. A coal-mining complex is located just across the border in Kazakstan where Jurassic coal-bearing strata are exposed at the surface. Currently, mining activity is in suspension because of economic competition with the more extensive and better developed coal deposits in central Kazakstan. The reason Chu is discussed in this report is that it is possible that the coal-bearing strata exposed in Kazakstan are present in the subsurface of Kyrgyzstan below Quaternary deposits in the area north of Bishkek. Seven oil and gas exploration holes have been drilled just southeast of Bishkek on an anticlinal structure. None of these holes encountered coal. At the time of our visit in the fall of 1994, an oil and gas exploration hole was being drilled near Kara Balta, about 60 km west of Bishkek. The hole had reached a depth of 1,500 m but was still in the Tertiary part of the section. The hole is scheduled for completion in Paleozoic strata at a depth of 3,000 m. The resource potential of the Chu region cannot be evaluated without exploration drilling for coal in the area immediately south of the border with Kazakstan.

C. RESOURCES AND RESERVES

1. Classification

There is no standard coal resource and reserve classification system that is applied worldwide. Two of the most widely used are the system adopted by the U.S. Geological Survey for use in the United States (Wood and others, 1983), and the system used in the former Soviet Union (Bybochkin and others, 1983; Modelevsky and others, 1979). In the USA system, resources are deposits of coal in such forms and amounts (thickness and depth) that economic extraction is currently or potentially feasible and identified resources are those resources whose location, rank, quality and quantity are known or estimated from specific geologic evidence. Reserve base is those parts of identified resources that meet specified minimum physical and chemical criteria related to current mining and production practices, including criteria for quality, depth, thickness, rank, and distance from points of measurement. Reserves are the parts of a coal reserve base which could be economically extracted or produced at the time of determination considering environmental, legal, and technologic constraints, and include only recoverable coal. An important point is that reserves are time-dependent -- today's resources may be tomorrow's reserves, and some of today's reserves may fail to be qualified for future economic conditions. In contrast, estimates of resources are relatively stable and are not necessarily responsive to changing technology, economics or politics.

In the former Soviet Union (FSU) system, the term "resources" is rarely used, and only in the sense of total geological resources. Usually, the term "reserves" is used, with modifiers, throughout the classification system, and "(total) geological reserves" is roughly resources in the USA system. Reserves in the western sense are dependent on the price of coal. In contrast, in the FSU classification system, the concepts of coal "price" and "value" are not as important and the term "reserves" may not imply economic recoverability today. The FSU term "reserves" (zapasy) does not necessarily mean that the market price of the coal equals or exceeds the cost of mining it, though "balance reserves" has somewhat that meaning.

In the FSU system "total geological reserves" are divided into "identified reserves" and "undiscovered reserves". "Identified reserves" are divided into "balance reserves" and "out-of-balance reserves". "Balance reserves" (commercial), are potentially recoverable and may be roughly equivalent to the economic portion of the identified resource category in the USA system. "Out-of-balance reserves" (noncommercial) are probably roughly equivalent to the subeconomic portion of the identified resource category of the USA system (fig.5).

Balance (commercial) reserves are further subdivided into categories A, B, C_1 and C_2 according to reliability of reserve estimation, and coal quality, and of mining conditions."(Kamenov and Zheleznova, 1984; Modelevsky and others, 1979).

Resources

In 1983, Dzhamanbayev reported the total energy resources of Kyrgyzstan, in percent, as follows:

Coal-----------------------52.97 percent
Shale---------------------- 0.25 percent
Peat------------------------0.06 percent
Water Resources--------45.21 percent
Other-----------------------1.51 percent

"Other" may be mostly oil and gas (See section II.E., Other Fossil Fuels.).

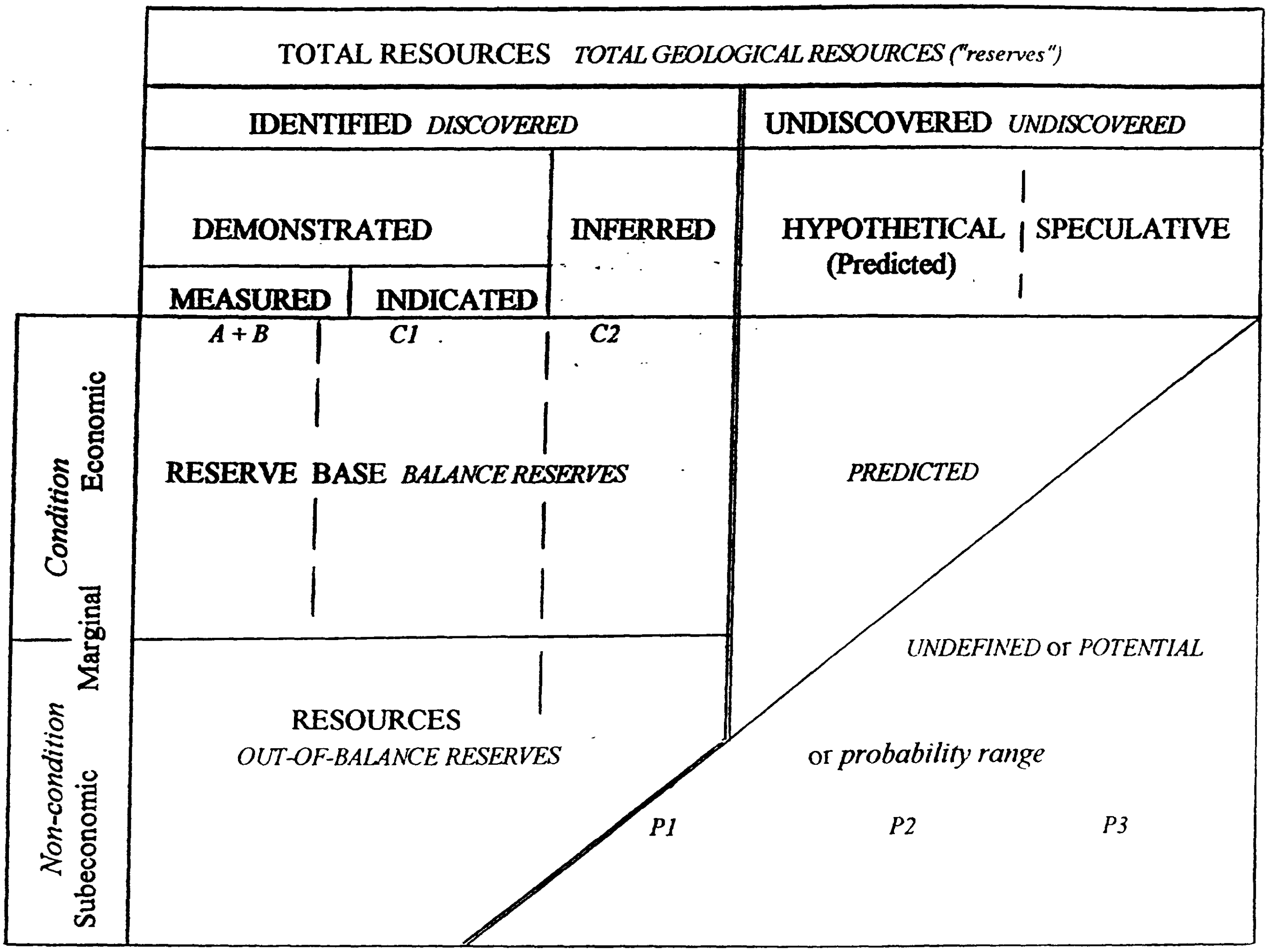

Figure 5. Approximate relationship of balance reserves and letter-designated reliability categories of the former Soviet Union resource classification system *(italics)* to equivalents in the U.S. Geological Survey system.

Dzhamanbayev further states that the general geological reserves (resources) of Kyrgyz coals in 1982 amounted to 31, 415 million metric tonnes, of which the balance reserve is 2,429 million tonnes. Kopylov (1977) presented an estimate of 28,352 million tonnes of total geological reserves with 2,236 million tonnes in the balance reserve group. Other available estimates do not differ significantly.

The relationship of the estimated total geological reserves of an area to the portion of the total that can be reliably categorized as balance reserves varies according to the amount and distribution of accurate information that is available. Matveev (1976) recognized large differences in the degree of coal exploration that has been conducted in various parts of the world and stated that the coal resources of the former Soviet Union and of the United States were both relatively poorly explored compared to the coal areas of Europe. For comparison, only about 8 percent of the total geological reserves of Kyrgyzstan are in the balance reserve category, about the same as the former Soviet Union, and about 11 percent of the total estimated coal resources of the United States are categorized as demonstrated reserve base (reserves that may be economically recoverable). Perhaps areas such as the FSU and USA, each with more than 400,000 million tonnes of well-defined reserves, can afford to be poorly explored. If coal is to continue to contribute a major portion of the energy budget of Kyrgyzstan, the country must evaluate its resources and actively explore for exploitable coal.

2. Coal availability

The numbers cited in the preceding paragraph indicate, at first glance, that there are ample available coal resources in the areas discussed. However, it has long been recognized in the United States and elsewhere that if the effects of mined-out prime coal reserves, and environmental, industrial, economic, and social considerations are "priced" and the value of the coal is considered, the amount of coal that would be available and economically recoverable would be far less than the amount classed as "demonstrated reserve base" [or as "balance reserves"] (Rohrbacher and others, 1993).

The U.S. Geological Survey, Kentucky Geological Survey and the U.S. Bureau of Mines have jointly addressed the problems of coal availability and recoverability in pilot programs designed to produce results of wide-ranging applicability. To date, eleven areas in the Central Appalachian Coal Field, each area a quadrangle about 150 square kilometers in size, have been studied. Results of the studies show that 1.6 to 36.4 percent of the original coal resources have been mined and lost-in-mining, but that only 13 to 35 percent remains as a recoverable resource, and that only 1.6 to 23.1 percent of the original resource can be classed as economically recoverable reserves (Rohrbacher and others, 1994 and Scott, D.C., 1995) (fig.6).

The above cited sources conclude that:, "*These results suggest that there may be several orders of magnitude of difference between coal resources and the amount of coal that can be economically recovered. If similar results are found in subsequent investigations, a strong argument can be made that traditional coal producing regions may experience resource depletion problems far greater and much sooner than previously thought. This will affect not only the coal industry, but the entire social and economic infrastructure of large areas.*"

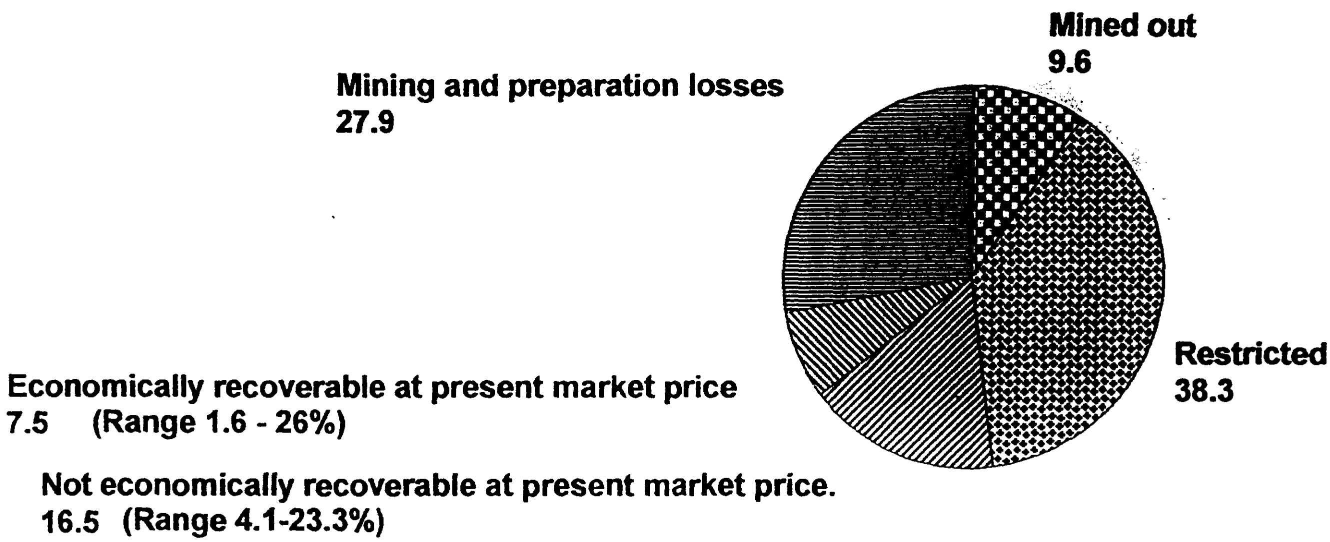

Figure 6. Percentage of original resources of 11 quadrangles of the central Appalachian coal field, U.S.A., in different recoverable and nonrecoverable categories (see text citations for sources).

Availability and recoverability studies of the coal areas in Kyrgyzstzan could be equally as enlightening and provide reliable data for energy and social planning for the future.

3. Area and Region Reserve Estimates

Estimates of the quantities of coal that are present in the known deposits in the former Soviet Union (FSU) have long been conducted under a uniform methodology designed to provide quantified understanding of the available coal resources according to physical and chemical categories. Other similar classification systems are used elsewhere in the world. The system used by the USGS (Wood and others, 1983) is widely accepted in concept and practice in various countries around the world.

The FSU estimation system and the USGS system are philosophically similar but methodologically different. The FSU system is somewhat more rigid and tends to deprecate extrapolation of data from known to unknown areas. The USGS system allows and encourages extrapolation. No comparative estimates were made for this study but examination of maps showing resource and reserve areas indicates that the two systems produce somewhat comparable results, especially for areas where there are more data. The FSU categories A plus B are approximately equivalent to the USA category "measured". The FSU category C_1 is approximately equivalent to the USA category "indicated". The FSU category C_2 is approximately equivalent to the USA category "inferred". The FSU categories P_1, P_2, and P_3 are approximately equivalent to the USA categories "hypothetical" and "speculative" (fig.5).

A very recent estimate of the amount of balance (commercial) and non-balance (noncommercial) reserves of Kyrgyzstan is as follows, in million tonnes:

Groups	Balance $A+B+C_1$	Balance C_2	Non-Balance
Brown coal	849	389	102
Bituminous coal and anthracite	431	593	84
Surface-mine reserves	305	31	15
Underground-mine reserves	989	951	171
Total	1294	982	186

The above estimate may reflect recent production and unspecified engineering parameters. All of the estimates indicate that the balance reserves of Kyrgyzstan, roughly equivalent to USA identified resources, may be dangerously small.

Table 1 is one of many attempts to summarize various bodies of information regarding the estimated reserves of the better-known coal areas in Kyrgyzstan. Some of the estimates have been updated periodically and reflect increased knowledge as exploration and development is conducted

Table 1. Estimated balance reserves in coal areas in Kyrgyzstan (millions of metric tonnes, rounded).

	$A+B+C_1$	C_2	Total
South Fergana Coal Region			
Kyzyl-Kiya	92	19	111
Abshir	10	3	13
Valakish	2	1	3
Sulyukta	193	14	206
Almalyk	20	0	20
Total	317	37	353
East Fergana Coal Region			
Kok-Yangak	123	15	138
Kumbel-surface	11	0	11
Kumbel-underground	18	11	29
Tuyuk	31	83	114
Kargasha	100	70	170
Beshterek	7	4	12
Kara-Tyube	33	66	99
Kok-Kiya	0	114	114
Zindan	17	31	48
Chitty	0	9	9
Total	340	403	744
North Fergana Coal Region			
Tegenek-surface	7	0	7
Tegenek-underground	48	4	52
Kara-Tut-surface	30	0	30
Kara-Tut-underground	12	6	18
Tash-Kumyr(Severnaya)	14	0	14
Tash-Kumyr(Other)	31	14	45
Total	142	24	166
Kavak Coal Region			
Agulak	48	18	67
Min-Kush(3 areas nearby)	38	125	164
Kashkasu	5	7	12
Kok-Maynok	61	69	130
Kara-Kiche-surface	194	1	195
Kara-Kiche-underground	118	125	244
Total	464	345	812
Issyk-Kul Coal Region			
Soguty	10	2	12
Dzhergalan	3	0	3
Dzhergalan(extended)	12	4	16
Total	25	6	31
Grand Total-above listed areas	1288	815	2106

and mining proceeds. How closely they represent remaining economically recoverable reserves in a western context is unknown.

Table 2 is an attempt to separate total estimated balance reserves into the portion that has been or is now closely involved in mining operations (and therefore may not be available for future use) and into the portion that has been explored but not exploited (and therefore may still be available for future use). The table shows some interesting relationships: 1) 62 percent of the total balance reserves are in the A+B+C_1 category; 2) In the inactive sectors alone the ratio between reserves in the A+B+C_1 category and in the C_2 category is about 1:1 (In other parts of the world the ratio would probably be 1:3 or more). 3) 65 percent of the A+B+C_1 category reserves are in "explored only" sectors; and 4) 80 percent are reserves for underground mining.

D. PHYSICAL AND CHEMICAL CHARACTERISTICS

1. Chapter summary and the concept of coal quality

The "quality" of coal depends on many things that influence how easily and profitably the coal can be produced and used. The location, quantity, position in the earth and ownership are considered elsewhere in this report. Physical and chemical properties of the coal are described here. These properties must be addressed systematically in their entirety; they can not simply be evaluated as "good" or "bad", for that depends on the particular time and situation and on the particular use.

The general nature of Kyrgyz coals is summarized here, and the systematic details are presented later.

a. Rank

Most Kyrgyz coals are subbituminous or high-volatile C bituminous rank in U.S. terms. In Kyrgyz terms they are brown-coal 3 or long-flame. In the international classification established after WW-II, and used still in Europe, their rank (class number) is "8". In the East Fergana (Uzgen Basin) region are coals with much higher rank, ranging up to anthracite.

Parameters described later in this chapter that may be used for various rank classifications are vitrinite reflectance, volatile matter (mineral-free or ash-free), heating value (various bases), and moisture content (inherent bed moisture). Some data on tar extracts and humic materials are available in the literature on Kyrgyz coals; these data have been used for ranking brown coals (Mironov, 1982; Taits and Andreyeva, 1983).

b. Heat yield

On an as-received basis most Kyrgyz coals can be produced with heat yields of 20 to 25 MJ/kg (4700-6000 kcal/kg, 8500-11000 Btu/lb). Some production is known to fall below 15 MJ/kg because of dilution with rock. Several mines yield coal with heat value slightly higher than the

Table 2. Kyrgyzstan balance coal reserves in areas developed for mining in contrast to balance reserves in explored but undeveloped areas.

Type of Reserves	Underground			Surface			Total		
	A+B+C1	C2	Total	A+B+C1	C2	Total	A+B+C1	C2	Total
Explored and Confirmed	901	749	1650	368	35	403	1269	784	2052
Within active shafts and pit sectors	342	40	382	315	31	346	657	71	728
Explored ONLY sectors	559	708	1264	53	4	57	612	712	1324

above ranges, and coals occur in the East Fergana (Uzgen) region with 30 MJ/kg and probably higher. This chapter lists heat values in MJ/kg, kcal/kg, and Btu/lb, on as-received and dry bases, and calculated to mineral- and ash-free bases.

c. Mineral and rock content, and ash fusion properties

The mineral and rock contents of coal are usually reported somewhat indirectly, as weight percent ash after high-temperature ashing, dry-coal basis. Data over many years show that the Kyrgyz mines produced coal with ash values as low as 3% and as high as 40%, but most mines were able to produce coals with 10-20% average ash through much of their history (table 7; Solpuyev, 1994). We report ash, both dry and as-received basis and some values of calculated mineral content for samples we collected (tables 4, 7, 10). We report 4-point softening and fusion data for ash from our samples, under both reducing and oxidizing conditions (table 14), but we do not yet have information on boiler practice in heat or electricity stations in Kyrgyzstan with which to evaluate these ash data with respect to fouling of combustion chambers.

d. Organic type of coal

Two very different ways of reporting organic type are common: 1) Visible identification of macerals under the petrographic microscope, 2) Indirect indication from chemical analysis, usually just by ratios of hydrogen, carbon and oxygen. This chapter gives both maceral group petrographic analyses and chemical analyses.

Petrographically, Kyrgyz coals have a greater range of composition than most U.S. and European coals -- mainly a greater content of inertinite. We did not find coals with large amounts of liptinite in our samples nor in the literature. The Kyrgyz coals with high inertinite content appear to be similar to some other high-inertinite coals in the former Soviet Union; they may be similar to many high-inertinite coals of India, Australia or South Africa.

Chemically, the Kyrgyz coals have lower H/C ratios for a given rank than many North American and European coals, and some Kyrgyz coals have element compositions that place them clearly in the "fusinization development line" which characterizes development of coals under oxidizing conditions.

e. Sulfur and other inorganic elements

The sulfur content of Kyrgyz coals is relatively low, with major coals reported to have not over 2% on average, but the range is very great, with individual values from several important mines as high as 7%(tables 7, 9; fig. 18). Three of our samples slightly exceeded 2%. We report data on three forms of sulfur in the coal (pyritic, organic, sulfate) (table 4) , but comparable data from the literature on Kyrgyz coals are sparse. We report the major and minor elements in coal ash (tables 11-13), which range greatly, but that is not unusual. Similar older data from Kyrgyzstan are reported. We report trace element content of our samples and explain their environmental significance, but have not yet found comparable older data on Kyrgyz coals.

2. Data and samples of this study

a. Kinds of raw data included

This chapter lists basic properties that characterize coals in Kyrgyzstan based on fifteen mine samples collected by the USGS at twelve separate deposits representative of existing mines and several potentially significant new mines. The data include the following which are commonly requested internationally to evaluate coals for utility combustion (Unsworth and others, 1991).

Heat Value (Specific Energy)
Total Moisture
Ash
Volatile Matter
Total Sulfur
Nitrogen
Chlorine
Hardgrove Grindability
Ash Fusion Character
Ash Major and Minor elements

In addition, we provide data used to evaluate processing and industrial use and environmental consequences of coal use.

Forms of sulfur
Free swelling index
Equilibrium moisture

Maceral group composition
Apparent specific gravity
Thirty two trace elements in the ash
"Environmentally sensitive elements" (chlorine, selenium and mercury), whole coal.

On numerous graphs we show the relationships between various parameters and also their general validity. Additionally, we compare these data with some published and unpublished older data on Kyrgyz coals, mostly from the Soviet era, so that the large body of older information on coal quality can be judged by our data.

b. Information not included

There is a significant amount of information on Kyrgyz coals which we do not present or discuss here because it is beyond the scope of this preliminary survey. For example, tests of pyrolysis behavior and products, mineral transformations at high temperature, semicoke and coke formation, sorptive properties, tar production and type, briquetting and pelleting tests, extraction with organic solvents, humic acid fractionation, etc. The potential value of such information is difficult to judge, for in the most accessible sources the data are usually presented isolated from the basic information about the character of each sample. However, the systematic field and laboratory records from the Soviet era appear to be preserved in large measure -- though the loss of access because of retirements, switching jobs, and emigration and even the physical loss or disorganization of records may be happening at an accelerating rate.

c. Source and nature of samples

The USGS team sampled coals from fresh mine faces at most sites (Table 3). Where possible, channels of consistent depth across the exposed coal were cut and bagged at the face. At several sites only grab samples were obtainable. Rarely was the entire seam sampled, however, because it was not exposed entirely or because hazardous and precipitous walls overhung it in surface pits. In several underground mines the samples represent nearly the entire mined seam. Samples were put in heavy plastic bags which were folded and sealed with tape; then each bag was put in a second bag and taped again. The intention was to make possible "bed moisture" determination. In this we succeeded well as judged by comparison of "as received" and "equilibrium" moisture, figure 7.

3. General coal chemistry (USGS samples)

Data from the basic analyses of coal are listed in table 4. They are repeated in figures with other data farther in this chapter.

Various coal users in different countries are accustomed to reporting data on different basis, for example "as-received" and "as-analyzed"; "with inherent moisture", "bed-moist" and "in-mine"; "working","as-shipped" and "as-delivered"; "air-dry" (room temperature) and "air-dry" (107C); "ash-free" and "mineral matter-free" (calculated from ash or weight of low-temperature ash). It is beyond the scope of this report to report data on all bases used, and in many cases it is difficult to determine accurately the true basis of an analysis. We attempt to present data in several forms 1) Common U.S. practice, 2) Common practice in the former Soviet Union (the basis of most Kyrgyz data), 3) Common international trade practice. Most of the basic analyses of the USGS samples were done under ASTM standards, as listed on the sheets of raw data in the appendix.

4. Coal rank / Organic maturation

a. Standard ASTM rank: Heat value and volatile matter (or fixed carbon)

In US practice, "rank", the degree of metamorphism or progressive alteration in the natural series from lignite to anthracite, is used in a restricted way for multiple channel samples that represent a seam (or designated part) in a particular region. None of our samples, and probably none of the samples listed in the literature, fit that restriction. However, the ASTM term *Apparent Rank* is valid for our samples since we describe the conditions of the sampling. The apparent ASTM rank of our samples is on table 5. We use "rank" also as a geological term equivalent to "organic maturation", but only the rank on table 5 is ASTM apparent rank.

Table 3. Regional location, latitude-longitude, and name of sites sampled by the USGS in October, 1994. The coal seam sampled and the interval, if a channel sample, are listed along with the label put on the sample bag.

ID	Rgn[1]	Site name	Lat. - N	Long. - E	Seam - sample type	m[2]	Bag label
K-1	SF	Abshir	40-12	72-24	? - grab (chunks)	—	Abshir
K-2	Kv	Ag-Ulak	41-42	74-3 2	6 - run of mine	—	AgUlak #1a+#1b
K-3	SF	Almalyk	40-18	72-42	? - chan : top 1/3	8	Almalyk
K-4	IK	Dzhergalan	42-30	78-48	V - chan : top 1/4+bot. 1/2	6	Dzhergalan #1
K-5	IK	Dzhergalan	42-30	78-48	IV - channel	3	Dzhergalan #2
K-6	EF	Kara-Tyube	40-48	73-48	III - channel (~1/2)	1.2	Dara-Dobo
K-7	Kv	Kara-Keche	41-44	74-48	Osn. - chan : <1/10	3	Kara-Keche #1A+1B
K-8	NF	Kara-Tut	41-25	72-14	? - chan : bot. 1 4	1.2	Kara-Tut #2
K-9	NF	Kara-Tut	41-25	72-14	? - chan : top 3 5	3	Kara-Tut #1
K-10	EF	Kok-Yangak	41-00	73-12	6 - chan : mid. 4 5	2	Kok-Yangak
K-11	EF	Kum-Bel	41-00	73-30	22 - grab	—	Kum-Bel
K-13	Al	Kyzyl-Bulak	39-42	72-56	? - channel	2	Sary-Mongol
K-14	NF	Tash-Kumyr, Severn.	41-18	72-12	3 - chan : upper	1	Tash-Kumyr #1
K-15	MF	Tash-Kumyr, Severn.	41-18	72-12	3 - chan : lower	1	Tash-Kumyr #2
K-16	SF	Valakish	40-12	72-06	? - chan : mid 3.4m	3.4	Valakish

[1]Regions: Al - Alay, SF - South Fergana, NF - North Fergana, EF - East Fergana (Uzgen), SC - South Central (Alabuga-Chatyrkyol), Kv - Kavak, IK - Isyk-Kul', Ch - Chu.

[2]Approximate stratigraphic thickness of sampled coal, meters.

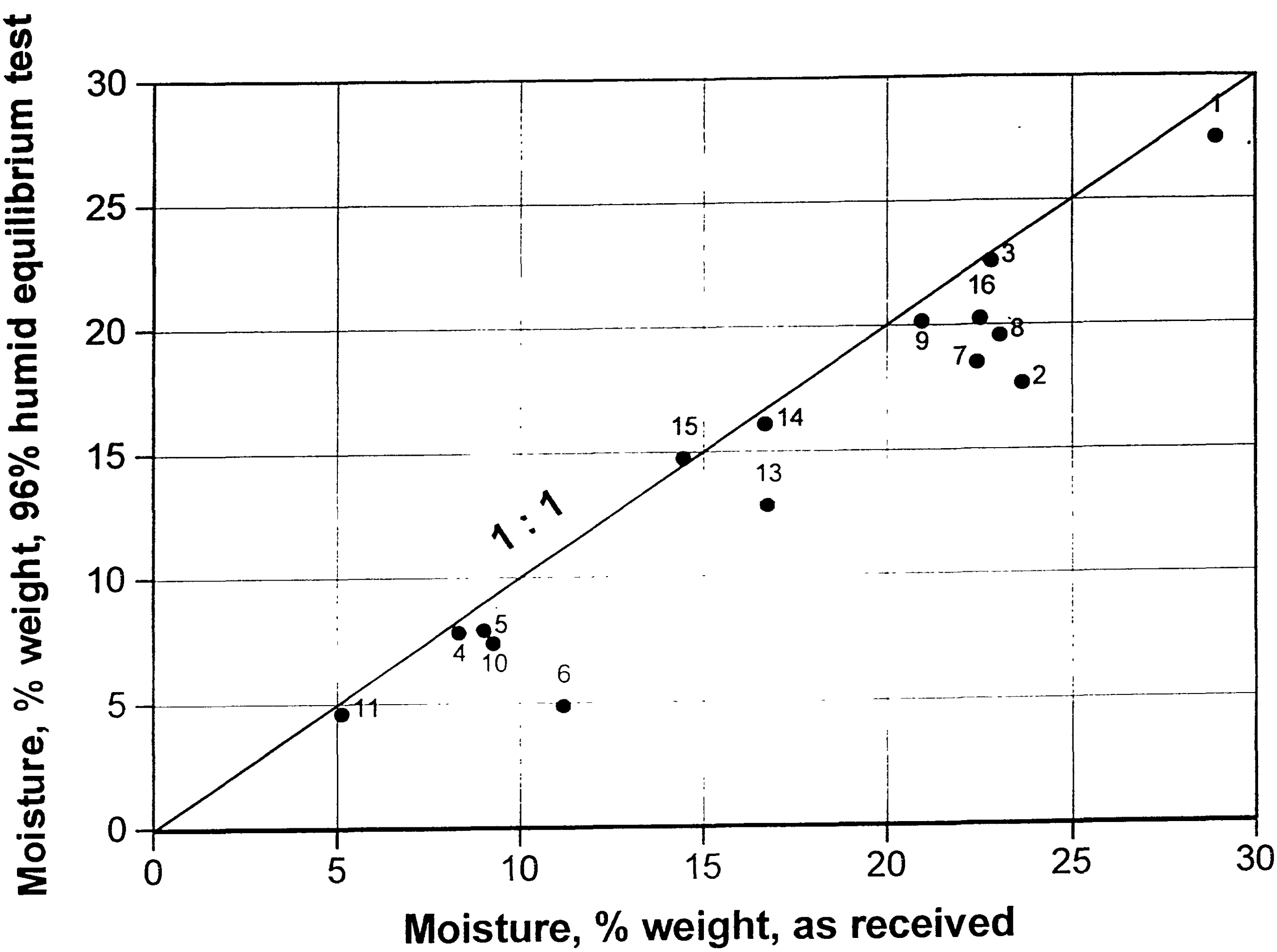

Figure 7. Equilibrium moisture in relation to as-received moisture of Kyrgyz coals sampled by the USGS.

Coal Analysis Report

Sample Id #	Location: Site Name	$\%W_{eq}$	Proximate Analysis, % weight: W_{ar}	A_{ar}	VM_{ar}	FC_{ar}	A_d	VM_d	FC_d	VM_{daf}	FC_{daf}	H/C atomic $(12 \times H)/C$	O/C atomic $(12 \times O)/(16 \times C)$
K-1	Abshir	27.47	28.92	4.69	31.58	34.81	6.60	44.42	48.98	47.56	52.44	0.821	0.129
K-2	AgUlak	17.64	23.68	11.18	24.28	40.86	14.64	31.81	53.55	37.27	62.73	0.692	0.119
K-3	Almalyk	22.54	22.83	27.17	25.50	24.50	35.21	33.05	31.74	51.00	49.00	0.898	0.192
K-4	Dzhergalan	7.81	8.33	6.61	35.27	49.79	7.21	38.47	54.32	41.46	58.54	0.723	0.117
K-5	Dzhergalan	7.89	9.02	8.92	29.58	52.48	9.80	32.51	57.69	36.04	63.96	0.656	0.118
K-6	Kara-Tyube	4.85	11.19	19.56	13.74	55.51	22.03	15.47	62.50	19.84	80.16	0.457	0.074
K-7	Kara-Keche	18.47	22.45	6.83	25.71	45.01	8.81	33.15	58.04	36.36	63.64	0.554	0.151
K-8	Kara-Tut	19.56	23.07	14.17	29.27	33.49	18.42	38.05	43.53	46.64	53.36	0.773	0.140
K-9	Kara-Tut	20.14	20.96	13.34	29.83	35.87	16.88	37.74	45.38	45.40	54.60	0.785	0.151
K-10	Kok-Yangok	7.37	9.27	11.64	25.87	53.22	12.83	28.51	58.66	32.71	67.29	0.554	0.098
K-11	Kum-Bel	4.60	5.13	8.31	37.13	49.43	8.76	39.14	52.10	42.89	57.11	0.765	0.092
K-13	Kyzyl-Bulak	12.81	16.76	3.18	31.26	48.80	3.82	37.55	58.63	39.04	60.96	0.681	0.130
K-14	Tash-Kumyr, Severn.	16.09	16.69	6.81	31.88	44.62	8.18	38.26	53.56	41.67	58.33	0.772	0.128
K-15	Tash-Kumyr, Severn.	14.75	14.46	13.13	31.52	40.89	15.36	36.85	47.79	43.54	56.46	0.787	0.135
K-16	Valakish	20.24	22.54	8.88	29.69	38.89	11.47	38.34	50.19	43.30	56.70	0.804	0.154

Sample Id #	Ultimate Analysis, % weight: H_{daf}	C_{daf}	N_{daf}	S^{org}_{daf}	O_{daf}	Gross Heating Value (Isoperibol) Btu/lb: Q_{ar}	Btu/lb: Q_{daf}	Kcal/kg: Q_{ar}	Kcal/kg: Q_{daf}	MJ/kg: Q_{ar}	MJ/kg: Q_{daf}	Forms of Sulfur, % weight: S^{tot}_d	S^{pyr}_d	S^{sul}_d	S^{org}_d
K-1	5.23	76.42	1.39	2.27	13.15	8927	13447	4959	7471	20.76	31.27	3.56	1.34	0.10	2.12
K-2	4.62	80.16	1.02	0.74	12.76	8812	13527	4896	7515	20.49	31.46	1.23	0.55	0.04	0.64
K-3	5.32	71.09	0.78	2.16	18.20	6154	12308	3419	6838	14.31	28.62	2.98	1.49	0.10	1.39
K-4	4.86	80.67	1.01	0.26	12.56	11759	13824	6533	7680	27.35	32.15	0.83	0.58	0.02	0.23
K-5	4.45	81.37	1.02	0.17	12.75	11353	13834	6307	7686	26.40	32.17	0.37	0.11	0.11	0.15
K-6	3.30	86.71	0.94	0.39	8.59	9799	14151	5444	7862	22.79	32.91	0.36	0.03	0.02	0.31
K-7	3.65	79.03	0.84	0.34	15.88	8991	12714	4995	7063	20.91	29.57	0.55	0.19	0.04	0.32
K-8	4.91	76.18	1.15	1.20	14.23	8420	13417	4678	7454	19.58	31.20	2.88	1.84	0.06	0.98
K-9	5.01	76.61	1.20	1.00	15.41	8747	13313	4859	7396	20.34	30.96	1.47	0.55	0.09	0.83
K-10	3.86	83.54	0.83	0.21	10.92	10966	13866	6092	7703	25.50	32.25	0.74	0.49	0.06	0.19
K-11	5.26	82.51	1.17	0.77	10.14	12482	14420	6934	8011	29.03	33.53	0.84	0.08	0.05	0.71
K-13	4.56	80.33	0.74	0.23	13.91	10914	13632	6063	7573	25.38	31.70	0.44	0.17	0.05	0.22
K-14	5.09	79.11	1.14	0.51	13.54	10340	13516	5744	7509	24.05	31.43	1.02	0.54	0.02	0.46
K-15	5.09	77.60	1.24	0.73	13.98	9779	13506	5433	7503	22.74	31.41	1.77	1.12	0.03	0.62
K-16	5.17	77.17	0.69	0.48	15.85	9025	13161	5014	7312	20.99	30.61	0.99	0.53	0.03	0.43

A = Ash
FC = Fixed Carbon
Q = Heating Value (calorific value)
VM = Volatile Matter
W = Moisture

C = Carbon
H = Hydrogen
N = Nitrogen
O = Oxygen
S = Sulfur

$_{ar}$ = As Received
$_{d}$ = Dry
$_{daf}$ = Dry Ash Free
$_{eq}$ = Equilibrium Moisture

^{org} = Organic
^{pyr} = Pyritic
^{sul} = Sulfate
^{tot} = Total

Table 4. Basic chemistry of coals sampled in October, 1994, by the USGS team in Kyrgyzstan.

Table 5. Apparent rank according to ASTM analyses and the ASTM ranking standard -- coals sampled in Kyrgyzstan in October 1994 by the USGS. An additional column shows ranking of coals from the same mines (in some cases the same seams) as evaluated by Solpuyev (1994), where B = brown coal, D = long flame coal, G= gas (flame) coal, T = lean coal. Another column shows separation of brown and stone coals according to their vitrinite reflectance -- one of the parameters used in the former USSR for ranking brown coals.
Below the table are listed coal rank terms used in the USSR with approximately equivalent rank as used in North America. Exact equivalence of a particular sample depends on conditions of sample handling and analysis as well as some variation in usage of terms in different parts of the coal industry in the USSR.

Field Sample Number	Name of site	D-MM-F Fixed Carbon	M-MM-F Btu / lb	Rank (ASTM)	USSR rank by Ro	USSR rank Solpuyer '94
K-1	Abshir	53.28	9408	Subbituminous C	B	B3
K-2	AgUlak	63.89	10028	Subbituminous B	B	B3
K-3	Almalyk	51.88	8703	Subbituminous C	B	B3
K-4	Dzhergalan	59.06	12679	hvC Bituminous	>	D
K-5	Dzhergalan	64.60	12570	hvC Bituminous	>	D
K-6	Kara - Tyube	82.15	12431	lv Bituminous	>	T
K-7	Kara - Keche	64.27	9709	Subbituminous B	B	B3
K-8	Kara - Tut	54.89	9954	Subbituminous B	B	D
K-9	Kara - Tut	55.78	10228	Subbituminous B	B	D
K-10	Kok - Yangok	68.29	12557	hvC Bituminous	>	D
K-11	Kum - Bel	57.70	13735	hvB Bituminous	>	G
K-13	Kyzyl - Bulak	61.24	11307	Subbituminous A	B	~
K-14	Tash - Kumyr, Severn.	58.94	11171	Subbituminous A	B	D
K-15	Tash - Kumyr, Severn.	57.65	11417	Subbituminous A	B	D
K-16	Valakish	57.49	9987	Subbituminous B	B	B3

USSR			USA	
Brown Coals		B1	ligB ligA	Lignite
		B2	subC	Subbituminous
		B3	subB	
Hard Coals	Long-Flame	D	hvCb\subA hvBb	
	Gas	G	hvAb	Bituminous
	Fat	Zh	mvb	
	Coking	K		
	Lean-Caking	OS	lvb	
	Lean	T	sa	
	Semi-anthracite	PA	an	Anthracitic
	Anthracites	A	ma	

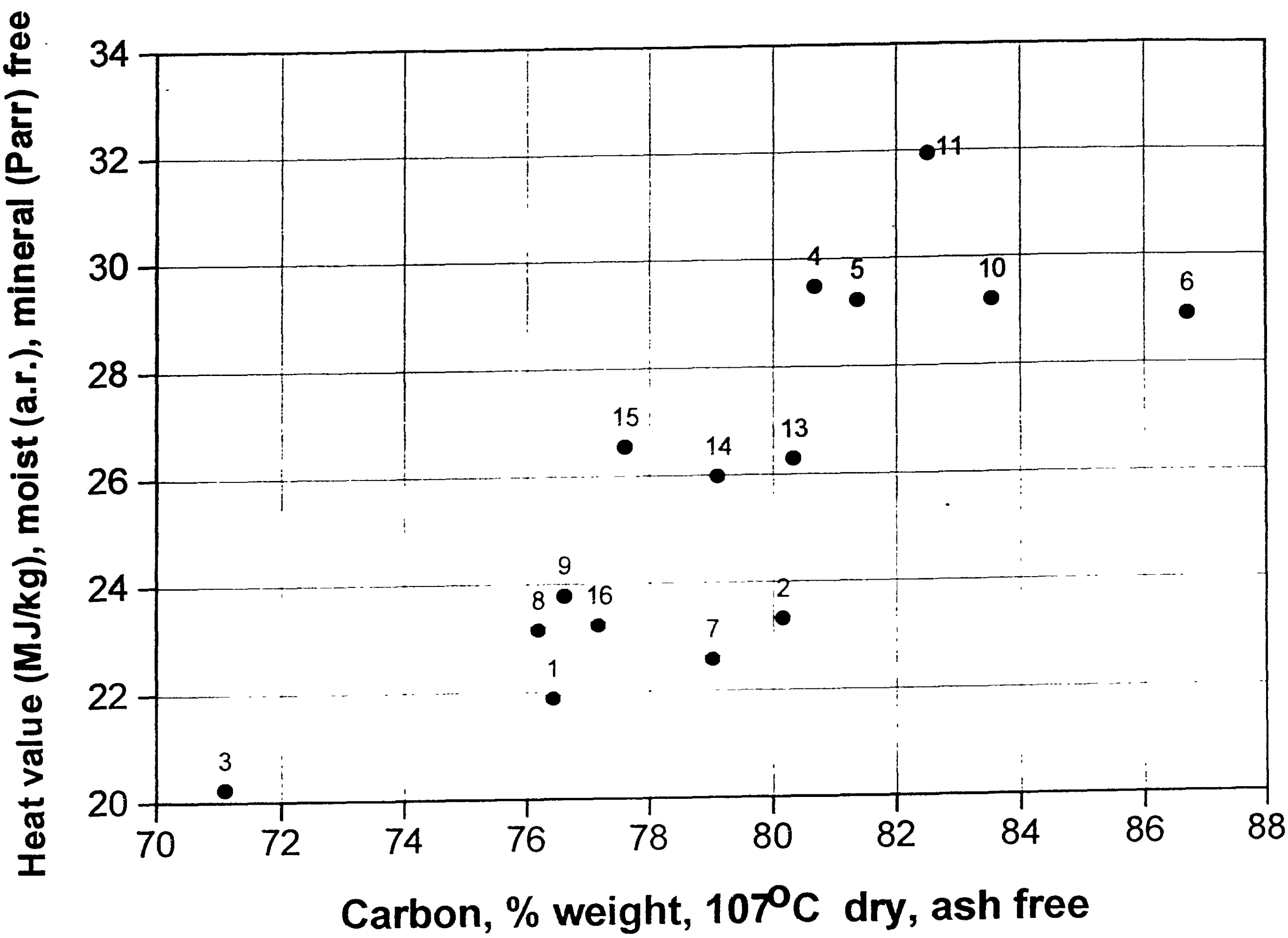

Figure 8. Heat value in relation to elemental carbon of Kyrgyz coals sampled by the USGS.

b. USSR rank of coals sampled by the USGS

With the exception of Kyzyl-Bulak (sample K-13), rank of coals at all the sites sampled by the USGS has been reported in the literature, and summarized recently by Solpuyev (1994). His USSR rank designation is in the right column on table 5. Most coals mined in Kyrgyzstan are the highest brown coal rank (B3) or the lowest stone coal rank (D, Long Flame). Our samples are representative, and five of the mines we sampled are cited as " B3" coal and seven are cited as " D" coal.

Because most coals of Kyrgyzstan are low rank (subbituminous and high volatile C bituminous [B3 and D]), the apparent rank is measured by heating value (calculated mineral-free). Only one of our samples, K-6, has relatively high rank and hence in the ASTM system is classified by volatile matter. Other parameters, such as elemental carbon, bed moisture, and vitrinite reflectance, are good measures of geological rank and are discussed in the following paragraphs on character of Kyrgyz coals.

c. Rank by elemental carbon, %Cdaf

Elemental carbon is a good chemical measure of rank, with perhaps the widest useful range of the chemical parameters. It is useful through the entire range of bituminous coals and anthracites, though volatile matter is better in the medium- and low-volatile bituminous range. The relationship between elemental carbon and heat value, two different measures of rank, forms a fairly narrow band (fig. 8), which shows the consistency of our sampling and our analysis.

d. Rank by vitrinite reflectance, %Ro

Vitrinite reflectance indicates rank over a wide range like elemental carbon does; reflectance has the additional advantage that it is more independent of coal type, and it is not influenced by minerals so can be used to rank coaly shales (but not reliably oil shales). The vitrinite reflectance of our Kyrgyz coals is on table 6 and is plotted against other rank measures: elemental carbon, figure 9; heat value, figure 10; and fixed carbon, figure 11.

5. General proximate and ultimate data

Basic analytical data of the USGS samples are in table 4 and are discussed earlier in this chapter. We gathered published and unpublished older data on Kyrgyz coals, some of which is on table 7, in order to relate the US data to data produced under sampling and analytical practice in the former USSR. We include here mainly information for the mines and seams we sampled.

The mineral matter in coal is not usually analyzed, but ash left after burning coal at high temperature is used as an inexpensive means to estimate the mineral content of coal, and the ash in a laboratory test is also an approximation of the ash left from industrial combustion. The ash reported in table 4 results from ASTM analysis at 750°C. ISO standard ash determination is at 815°C, and recent practice in the USSR agrees with ISO (800-830°C range). Note, however, that

Sample	Location	USGS						USGS	Literature		
Id	Site	%R_o	%C_{daf}	%FC	$Q_{w,mf}$			Q_{daf}	Q_{daf} (Kcal/kg)		
#	Name			d,mmf	Btu/lb	MJ/kg	Kcal/kg	Kcal/kg	minimum	maximum	average
K-1	Abshir	0.33	76.42	53.28	9408	21.88	5227	7471	5200	7400	6515
K-2	AgUlak	0.44	80.16	63.89	10028	23.33	5571	7515	6438	7446	6954
K-3	Almalyk	0.38	71.09	51.88	8703	20.24	4835	6838	4513	7993	7061
K-4	Dzhergalan	0.50	80.67	59.06	12679	29.49	7044	7680	7191	7884	7549
K-5	Dzhergalan	0.57	81.37	64.60	12570	29.24	6983	7686	7286	7788	7573
K-6	Kara-Dobo	1.86	86.71	82.15	12431	28.91	6906	7862	8103	8770	8603
K-7	Kara-Keche	0.47	79.03	64.27	9709	22.58	5394	7063	4998	7802	6902
K-8	Kara-Tut	0.40	76.18	54.89	9954	23.15	5530	7454	6111	7986	7180
K-9	Kara-Tut	0.39	76.61	55.78	10228	23.79	5682	7396	6111	7986	7180
K-10	Kok-Yangok	0.65	83.54	68.29	12557	29.21	6976	7703	4109	8123	7550
K-11	Kum-Bel	0.75	82.51	57.70	13735	31.95	7631	8011	7501	8457	7931
K-13	Kyzyl-Bulak	0.43	80.33	61.24	11307	26.30	6282	7573	4535	4989	4794
K-14	Tash-Kumyr, Severn.	0.49	79.11	58.94	11171	25.98	6206	7509	6945	7554	7360
K-15	Tash-Kumyr, Severn.	0.45	77.60	57.65	11417	26.56	6343	7503	6859	7597	7215
K-16	Valakish	0.40	77.17	57.49	9987	23.23	5548	7312	6047	7900	6558

Table 6. Chemical parameters used to measure coal rank; vitrinite reflectance and heat value from USGS analyses, plus heat value of coals from the same sites from the literature for comparison.

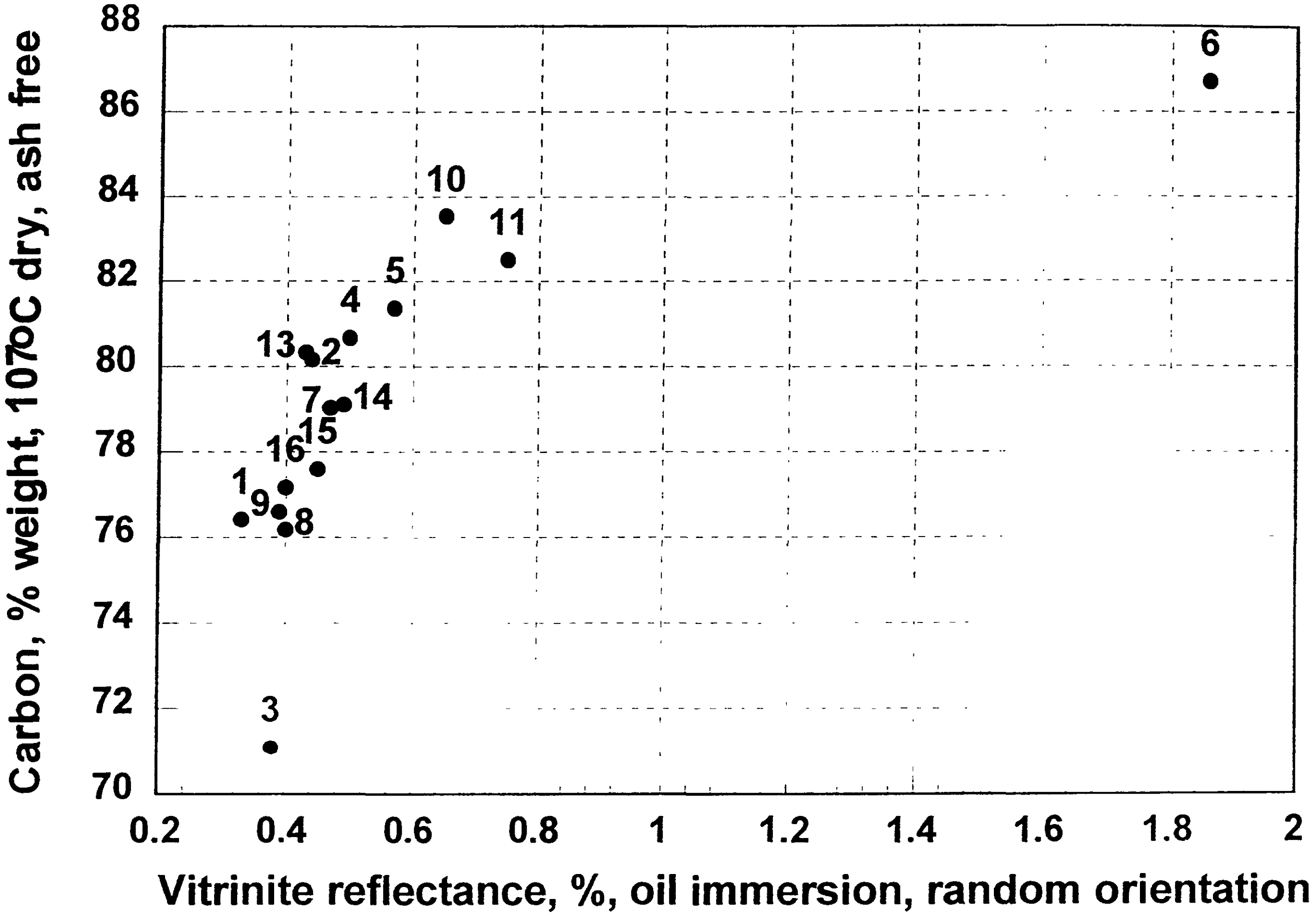

Figure 9. Elemental carbon in relation to vitrinite reflectance of Kyrgyz coals sampled by the USGS.

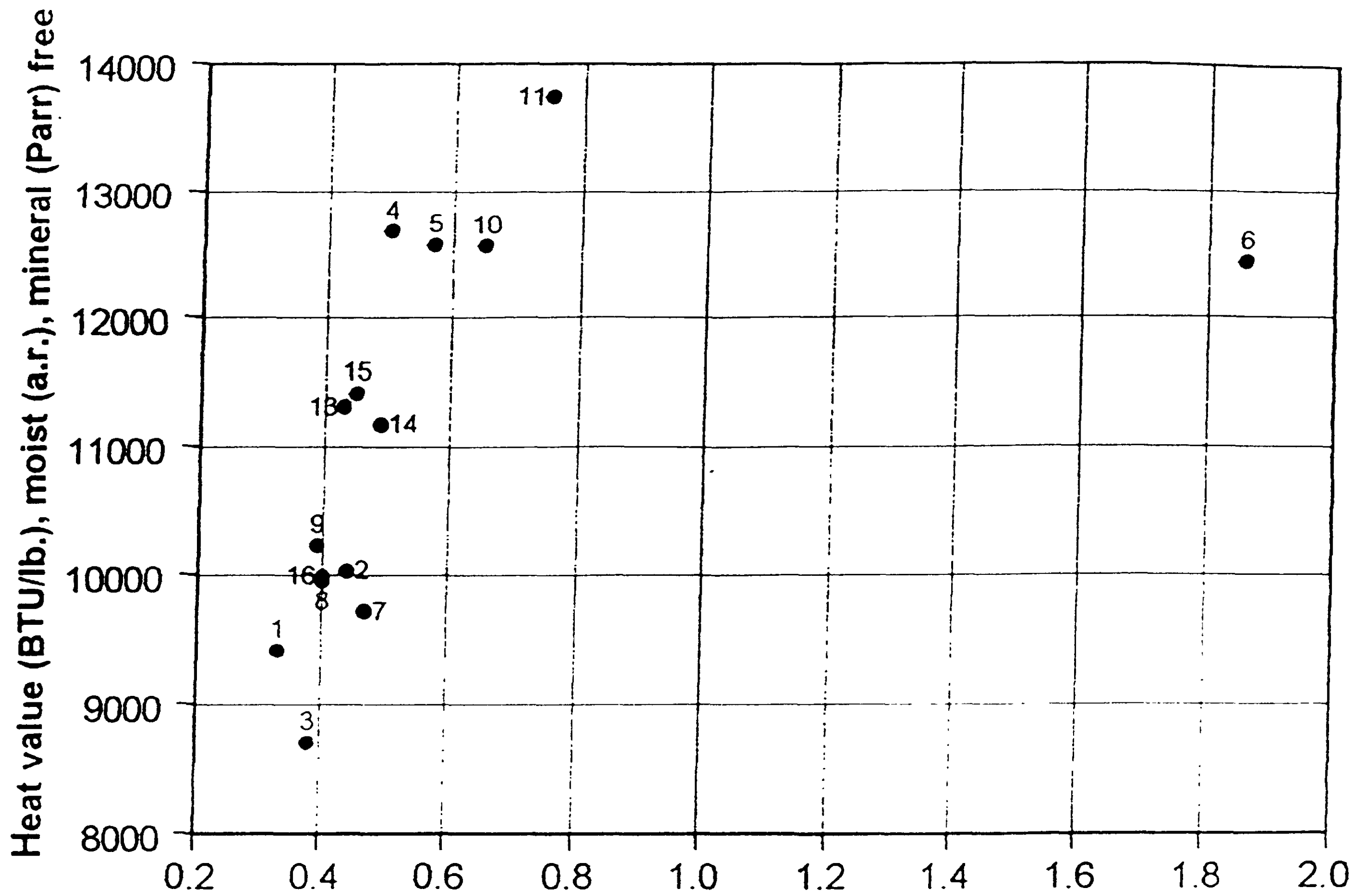

Figure 10. Heat value in relation to mean random vitrinite reflectance of Kyrgyz coals sampled by the USGS.

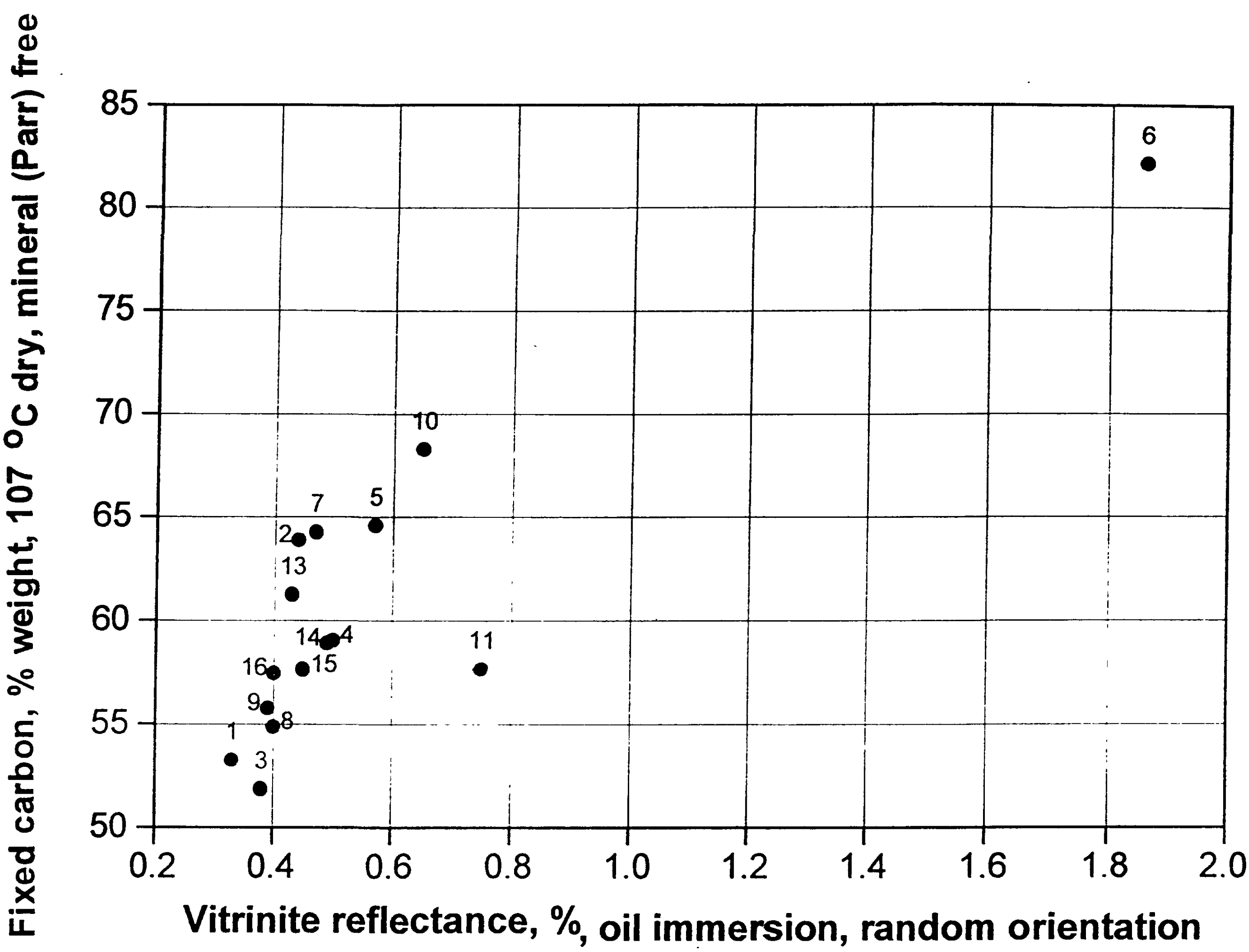

Figure 11. Fixed carbon in relation to mean random vitrinite reflectance of Kyrgyz coals sampled by the USGS.

Table 7. Main data from proximate and ultimate analysis of coals sampled by the USGS and data from the literature on the same mines, in some cases stated to be from the same seams sampled by the USGS.

Sources of literature data (page where most data is found given for each row): 1=Kamenov B 1984; 2=Dzhamanbayev 1983; 3=Solpuyev 1994, Vol.1; 4= Solpuyev 1994, Vol.2

W,r = "rudnichnaya" (= in situ), or sometimes "rabochaya" (= as produced) moisture, whole coal.
W,a = "as analyzed", or ASTM "as-received" moisture, whole coal

TbCh9.wpd {t9}

Source	Site	Seam	%W,r	%Wa	%A,d	%S,d (total)	V,daf	Q,daf (kcal/kg)	%C, daf	%H, daf	N+S+O,daf
USGS k-1	Abshir		29		7	3.6	48	7471	76	5.[illegible]	17
3p111	Abshir	Osn.[1]		5-19 11	5-30 18	0-8 3.0	25-65 43	6000-7400 6246			
3p110[2]	Abshir	Osno vnoy	27-29 28/5		19-24 22/5	1.3-2.6 1.8/5	39-45 41/5	5213-6648 5806/5			
3p111	Abshir	Mono klinal		3-11 7	10-30 20	0-9 4.5	15-60 44	6100-7100 6658			
3p111	Abshir[3]	Osn.[4]		5-15 9	0-30 19	0-7.0 3.4	35-60 45	5400-7400 6515	50-76 68/68	2.0-5.94.2/68	13-49 27/68
USGS k-2	AgUlak	6	24		15	1.2	37	7515	80	4.6	14
2p16	Agulak	Verc hnyy		13	8	1.9	36	6708	77	4.6	-
2p16	Agulak	7		7	-	1.4	36	7300	77	5.3	18
2p16	Agulak	6		8-10	16-18	1.0-1.7	34-37	7395	78	3.8	18
3p73	Agulak[5]	6		4-10 7/1286	5-32 16/1286	.4-3.0 1.4/1167	29-39 34/1166	6438-7446 6954/1085	70-80 76/16	2.8-4.7 4.1/16	16-29 23/16
4p70	Agulak[6]	6	20-21/4		14-15/4	0.8-0.9/4	38-40/4	5760-5800/4			
USGS k-3	Almalyk		23		35	3	51	6838	71	5.3	21

[1]Osnovnoy from eastsern pit.

[2]1984 Data from KNIUI and VUKhiN; location details given & thickness

[3]Proximate source not given; Ultimate from Topl. Lab. BPI, but seam and location not stated.

[4]Osnovnoy from western pit

[5]Corehole samples: p.73, line 2, Seam 6 only; Ultimate p.75; NSO by Stot. addition.

[6]Listed as one of Minkush sectors (Tura-Kavak, Agulak, Lzapadnyy and Vostochnyy); here samples "central part of pit", southern also given

Source	Site	Seam	%W,r	%Wa	%A,d	%S,d (total)	V,daf	Q,daf (kcal/kg)	%C, daf	%H, daf	N+S+ O,daf
2p43	Almalyk			12	23-25 23	1.3- 2.0 1.9	44-45 45	6800	74	4.8	21
3p120	Almalyk[7]		22-30 28		20-35 30/23[8]	1.7	43-47 46/4	7099			
3p124	Almalyk[9]	Osno vnoy	23-24		27-35	1.3- 1.6	46-47	4840-4902			
3p120	Almalyk[10]		25-31 27/11 4		17-34 25/11 4[11]	0.2- 7.0 1.5/12 97	24-60 44/186 9	4513-7993 7061/939	55-80 73/12 6	3.1- 9.2 6/132	17-36 22
2p47	Beshterek. (Rn=K-PZh)		4-6	0-4	28-29	1.4- 2.8	31-34	8614-8664	86-88	5.0- 5.7	
USGS k-5	Dzhergalan	IV	9		10	0.4	36	7686	81	4.4	14
USGS k-4	Dzhergalan	V	8		7	0.8	41	7680	81	4.9	14
4p118	Dzhergalan	IV		04- 3.0 1.5/1 66	3-30 12/94	0-1.8 0.6/14 9	32-46 38/101	7286-7788 7573/78	75-82 79/10	4.3- 5.6 4.8/10	12-22 16/7
4p118	Dzhergalan	V		0.5-4 1.9/4 01	3-30 12/94	0-2 1.1/32 0	30-46 38/343	7191-7884 7549/293	69-85 79/57	3.1- 5.4 4.5/57	8-22 16/35
2p26	Dzhergalan		8-12 10	3-6 4	4-17 10	0.6- 2.1 0.8	35-44 40	7350-7770 7560		4.8	
USGS k-6	Kara-Tyube[12]		11		22	0.4	20	7862	87	3.3	10
3p219	Kara-Tyube	[13]									
3p21 9-220	Kara-Tyube	III		0-12 2/51	3-29 10/51	0.4- 1.1 0.7/16	4-13 8/43	8103-8770 8603/7	85-93 91/5	3.4- 4.4 3.8/5	3.15
3p22 1-222	Kara-Tyube	III	1	1	6	0.4	9	8763	93	4.2	3

[7]Mine sample; may be source of ultimate analysis.

[8]Mined coal + rock

[9]Three face samples, 1984; 14-29m seam

[10]Borehole samples, but source of ultimate analyses not clear

[11]Coal without rock that might be mined.

[12]Kara-Dobo

[13]219-221 gives Prox/ult for 4 seams in two sectors; See USGS sample notes to see which to use.

Source	Site	Seam	%W,r	%Wa	%A,d	%S,d (total)	V,daf	Q,daf (kcal/kg)	%C, daf	%H, daf	N+S+ O,daf
2p47	Kara-Tyube (Rn=PS-1)			0-11	7-19	1.0- 1.1		8103-8845	86-94	3.2- 4.3	
USGS k-7	Kara-Kiche		[illegible]		9	0.6	36	7063	79	3.6	17
4p86	Kara-Kiche	Slozh nyy		8-20 13/10 8	6-39 18/16 0	.2-8.0 2.2/15 5	25-50 39/155	5151-7325 6546/152	52-87 70/10 2	2.5- 5.2 4.3/10 2	18-52 27/61
2p23	Kara-Kiche	Osn.	4-35 20		4-25 9	0.1- 1.8 0.8	25-45 34	Qr/n	56-90 77	3.1- 6.2 4.6	+
2p23	Kara-Kiche	Slozh .	11-24 17		9-26 17	0.2- 2.9 1.5	25-50 39	Qr/n	63-78 73	2.5- 5.0 4.2	+
2p26	Kara-Kiche		25-32 27	11-14 14	6-11 9	0.4- 1.8 0.8	35-46 42	6010-7200 6605		3.6	
4p86	Kara-Kiche	Osno vnoy		4-18 12/10 88	4- 30/12 /2175	0-2.3 1.0/21 21	21-49 36/201 3	4998-7802 6902/2031	55-90 76/10 36	2.2- 6.2 4.3/10 36	6-38 22/99 4
USGS k-8	Kara-Tut		23		18	2.9	47	7454	76	4.9	17
USGS k-9	Kara-Tut		21		17	1.5	45	7396	77	5	18
4p31	Kara-Tut	Osno vnoy[14]	15	7	19	0.8	39	7406	77	4.4	18
4p30	Kara-Tut[15]			10-12 11/10	11-19 16/10	1.0- 3.9 2.1/10	38-44 42/10	6364-7415 7167/10			
4p30	Kara-Tut[16]			1-24 10/15 41	4-40 22/15 31	0.2- 2.8 1.0/10 26	32-64 43/109 9	6111-7986 7179/901			
2p47	Kargasha			3-12	25-35	1.0- 3.5	41-48	8368-8850	83-86	5.4- 8.4	
USGS k-10	Kok-Yangak		9		13	0.7	33	7703	83	3.9	12

[14]14 borehole samples analyzed by Bishkek Polytechnical Inst.

[15]Run of mine samples, 1955 "possibly weathered"

[16]Borehole samples, 1982-84

Source	Site	Seam	%W,r	%Wa	%A,d	%S,d (total)	V,daf	Q,daf (kcal/kg)	%C, daf	%H, daf	N+S+ O,daf
3p137	Kok-Yangak	6		2-19 6/162	2-35 12/23 2	0-7.4 1.2/57	24-48 38/47	4109-8123 7549/56			
3p135	Kok-Yangak	5+6[17]	7-9 9/8	2-7 4/26	7-31 18/45	0.2-4 1.9/12	24-37 32/33	7162-7683 7501/12	82[17]	4.5-5.0	12
3p138	Kok-Yangak	6	9/8		17'8	1.1/8	35/8	7573/8			
2p37	Kok-Yangak		12-21 14	1-17 12	7-20 12	0.3-4.9 1.8	31-38 34		74-79 78	3.3-6.0 4.9	
3p139	Kok-Yangak	5+6	10/9		16/9	1.1/9	34/9	7501/9			
2p43	Kok-Yangak			6-10 7	3-19 14	0.9-3.6 1.3	27-42 33	7740	78	5	15
3p138	Kok-Yangak[18]	5	10/2		22/2	0.8/2	27/2	6651/2			
USGS k-11	Kum-Bel		5		9	0.8	43	8011	82	5.3	12
2p47	Kum-bel (Rn=D-G)		?	5	20	0.3-1.0	37-40	8203	81	5.5	
3p157	Kum-Bel	K22[19]		0-19 4/69	8-34 19/42	0.4-1.8 0.8/24	22-58 40/24	7501-8457 7931/20	81	5.5	13
2p43	Kyzyl-Kiya			20-24 23	9-14 11	1.2-2.8 1.6	35-38 37	6650	76	4.4	20
2p39	Kyzyl-Kiya		24-28	19-24 23	10-17 16	1.2-4.6 4.4	29-40 35	4685-5550	67-78 72	3.7-4.9 4.5	
USGS k-13	Kyzyl-Bulak		17		4	0.4	39	7573	80	4.6	15
3p129	Kyzyl-Bulak[20]			8-20 10/54 [21]	5-26 12/54	0.1-0.3 0.2/16	42-49 45/16	4535-4989 4794/15			
2p26	Soguta.		17-18 17	8-18 10	8-22 14	0.3-3.0 1.1	40-42 42	6960-7350 7155		6	

[17]Kok-Yangak mine: Severnaya and Markay also given; also data on Seams: I,V,VI, Moshchnyy

[18]"Active mine", 1984, Inst. KNIUGI and VUKhIN; Seams 5 & 6 &5+6 listed

[19]Prox. given separately for seams 6,8,9.12.14.16.18.20.21.22.24.25; Ult.for 9,14,20,22

[20]Sampled as Sary-Mongol; 33-44'N, 72-54'E at 3200m elev.; "discovered by herdsmen of Sary-Mongol Sovkhoz in 1993"

[21]Why so many analyses if opened just since '93?

Source	Site	Seam	%W,r	%Wa	%A,d	%S,d (total)	V,daf	Q,daf (kcal/kg)	%C, daf	%H, daf	N+S+ O,daf
2p40	Sulyukta		17-21 20	17-22 19	7-21 12	0.5- 0.8 0.6	28-39 33	5055-6000 5201	74-78 76	3.8- 5.1 4.6	
2p43	Sulyukta			8-12 10	8-18 11	0.2- 0.8 0.6	28-48 36	5040	77	4	19
USGS k-15	Tash-Kumyr Severnaya	III low	14		15	1.8	43	7503	78	5.1	16
USGS k-14	Tash-Kumyr Severnaya	iii-upper	17		8	1	42	7509	79	5.1	15
4,p17	Tash-Kumyr. Severnaya-1	III		3-15 8/11	4-24 16/14	0.4- 3.4 1.2/9	37-43 40/9	6945-7554 7360/8			
3p18	Tash-Kumyr Severnaya 2	III		4-18 10/23 2	5-32 13/95	0.4- 7.1 1.1/17 2	30-47 41/175	6859-7597 7215/175			
2p43	Tash-Kumyr			7-10 9	6-15 11	0.5- 2.2 1.3	34-41 37	7200-7400 7315	78	5	16
2p33	Tash-Kumyr		7-9 8	7-9 8	5-25 11	0.2- 2.0 0.7	27-36 33		77-80 79	4.5- 5.3 4.9	
2p32	Tash-Kumyr[22]			3-16 7	4-31 16	0.1- 7.9 1.2	26-46 37	5265-8412 7433			
2p47	Tuyuk. (Rn=PK)			1-3	12-16	0.6- 1.2	33-38	8515-8609	87-90	5.8- 8.1	
USGS K-16	Valakish		22		11	1	43	7312	77	5.2	17
3p76	Valakish (Uchkorgon) [23]			2-37 14/25 2	8- 34/19 /238	0.3- 3.6 1.4/25 2	35-82 51/252	6047-6955 6492/169	69-78 75/31	4.0- 6.2 5.5/31	14-24 19/31[24]
3p76	Valakish. (Uchkorgon)[25]			10-17 13/20	11-33 18/20	0.7- 3.7 1.4/20	36-43 39/20	6386-7900 7120/20			
2p47	Zindan (Rn=G)		11-14	0-2	23-24	0.4	33	8230	85-86	5.0- 5.1	

[22]Picked the 6 column max-min and averaged averages.

[23]YuKGI data; HCNO data may be of mixed source

[24]Addition of separate N, O, Stot., max. & min. is approximate combined.

[25]BPI data

USSR practice uses a different slow heating sequence in analysis of brown coals and in analysis of stone coals; since produced Kyrgyz coals are about half brown coal and half stone coal, there may be some discontinuity in the Soviet data on ash. USGS analyses for this project included ashing also at 900°C in preparation for analysis of the major / minor / trace elements. All but three samples yielded equal or slightly lower ash at the higher temperature, but the difference is small (table 10).

6. Organic matter composition and type

a. Maceral composition (group analysis)

We petrographically analyzed the maceral group proportions in the USGS samples by visual point counting on polished sections of crushed coal. The resulting data are, therefore, volume estimates based on area – not weight – of each component. Table 8 lists the results on three bases: 1) Total point count of four maceral groups plus minerals, 2) Mineral percent plus percentage of four maceral groups on a mineral-free basis, 3) Three maceral group percentages (vitrinite, inertinite, liptinite) on a mineral- and mixtinite-free basis. Mixtinite is very fine organic matter, which can not be identified reliably by optical microscopy, mixed with some fine mineral matter. Using blue-excitation fluorescence it is seen to include much liptinite, but point counting this liptinite is unreliable because fluorescent objects below the polished surface could be counted by mistake. We estimate that the mixtinite contains roughly 1/3 vitrinite, 1/3 minerals, 1/3 liptinite, and only a small amount of inertinite. If the mixtinite-free data on table 8 had an added share of liptinite to account for the liptinite in the mixtinite, the indicated liptinite content would be increased significantly, by several percent, in the high-mixtinite samples.

Figure 12 is a ternary diagram of the maceral group percentages which shows the great range of composition and allows comparison with other data. The great abundance and range of inertinite places many Kyrgyz coals far outside the range of most U.S. and European coals. This should be kept firmly in mind by engineers and other coal specialists. Technology of some important Jurassic coals in the former USSR and technology of "Gondwana" coals from India and Pakistan, Australia, South Africa, and Brazil may be more applicable to Kyrgyz coals than would be technology familiar in North America and Europe.

Petrographic analyses from older USSR literature and unpublished analyses given in Solpuyev (1994) are compared with our analyses of samples from the same mines (fig.13). In about half the cases we have information that the samples reported are from the same seam we sampled. The agreement is notable -- much better than agreement of our analyses of major and minor elements, for instance, even though maceral analyses can be very subjective. One explanation for the good agreement comes to mind: Maceral analyses are rarely done on chance grab or run-of-mine samples, but usually on high quality channel samples or core.

b. Elemental H, C, N, O composition

The type of organic matter in coal is indicated chemically by the content of hydrogen, carbon, and oxygen. Normally the nitrogen and sulfur content is reported at the same time as other organic

Table 8. Maceral group percentage in coals sampled by the USGS in Kyrgyzstan. Point counting on polished sections of crushed splits of each sample was done by N. Bostick, USGS, under white light. Mineral matter and mixtinite was counted at the same time, and the calculations of mineral- or mixtinite-free basis at the right of the table used these counts. Mixtinite is very fine organic matter, which can not be identified reliably by optical microscopy, mixed with some fine mineral matter.

Sample Id #	Location Site Name	Seam and Sample Type	Sample Prep Number	Point count of macerals Mnl	Vt	In	Lpt	Mxt	N
K-1	Abshir	? - grab (chunks)	2023	91	835	158	30	89	1203
K-2	AgUlak	6 - run of mine	2025	203	207	706	23	225	1364
K-3	Almalyk	? - chan : top $^1/_3$	2027	549	584	97	20	139	1389
K-4	Dzhergalan	V - chan : top $^1/_4$+bot. $^1/_2$	2029	66	423	566	18	31	1104
K-5	Dzhergalan	IV - channel	2031	111	188	876	30	95	1300
K-6	Kara-Tyube	III - channel (~$^1/_2$)	2033	66	650	143	1	279	1139
K-7	Kara-Keche	Osn. - chan : <$^1/_{10}$	2035	30	122	948	48	36	1184
K-8	Kara-Tut	? - chan : bot. $^1/_4$	2037	243	539	455	33	252	1522
K-9	Kara-Tut	? - chan : top $^3/_5$	2039	550	549	181	20	84	1384
K-10	Kok-Yangok	6 - chan : mid. $^4/_5$	2041	359	271	746	9	20	1405
K-11	Kum-Bel	22 - grab	2043	70	1118	30	19	37	1274
K-13	Kyzyl-Bulak	? - channel	2045	85	462	607	15	35	1204
K-14	Tash-Kumyr, Severn.	3 - chan : upper	2047	122	813	444	39	64	1482
K-15	Tash-Kumyr, Severn.	3 - chan : lower	2049	188	453	258	34	153	1086
K-16	Valakish	? - chan : mid 3.4m	2051	261	429	374	16	125	1205

Sample Id #	Location Site Name	Mineral[1] Percent	USGS Vt/In	Literature Vt/In	Mineral Free Percent[2] Vt	In	Lpt	Mxt	Mixtinite - Free Percent: Mineral Free[3] Vt	In	Lpt	Mineral[4] %
K-1	Abshir	7.6	5.28		75.1	14.2	2.7	8.0	81.6	15.4	2.9	8.2
K-2	AgUlak	14.9	0.29		17.8	60.8	2.0	19.4	22.1	75.4	2.5	17.8
K-3	Almalyk	39.5	6.02	10.00	69.5	11.5	2.4	16.5	83.3	13.8	2.9	43.9
K-4	Dzhergalan	6.0	0.75	0.50	40.8	54.5	1.7	3.0	42.0	56.2	1.8	6.2
K-5	Dzhergalan	8.5	0.21	0.20	15.8	73.7	2.5	8.0	17.2	80.1	2.7	9.2
K-6	Kara-Tyube	5.8	4.55	2.00	60.6	13.3	0.1	26.0	81.9	18.0	0.1	7.7
K-7	Kara-Keche	2.5	0.13	0.40	10.6	82.1	4.2	3.1	10.9	84.8	4.3	2.6
K-8	Kara-Tut	16.0	1.18	1.90	42.1	35.6	2.6	19.7	52.5	44.3	3.2	19.1
K-9	Kara-Tut	39.7	3.03	1.90	65.8	21.7	2.4	10.1	73.2	24.1	2.7	42.3
K-10	Kok-Yangok	25.6	0.36	2.50	25.9	71.3	0.9	1.9	26.4	72.7	0.9	25.9
K-11	Kum-Bel	5.5	37.27	31.00	92.9	2.5	1.6	3.1	95.8	2.6	1.6	5.7
K-13	Kyzyl-Bulak	7.1	0.76		41.3	54.2	1.3	3.1	42.6	56.0	1.4	7.3
K-14	Tash-Kumyr, Severn.	8.2	1.83	14.00	59.8	32.6	2.9	4.7	62.7	34.3	3.0	8.6
K-15	Tash-Kumyr, Severn.	17.3	1.76	14.00	50.4	28.7	3.8	17.0	60.8	34.6	4.6	20.2
K-16	Valakish	21.7	1.15		45.4	39.6	1.7	13.2	52.4	45.7	2.0	24.2

Area percents calculated form point count as estimated volume percents.

[1] = [Mnl / (Mnl+Vt+In+Lpt+Mxt)] 100 = mineral %

[2] = [maceral type / (Vt+In+Lpt+Mxt)] 100 = % maceral type Mnl free

[3] = [maceral type / (Vt+In+Lpt)] 100 = % maceral type Mxt & Mnl free

[4] = [Mnl / (Mnl+Vt+In+Lpt)] 100 = mineral % Mxt free

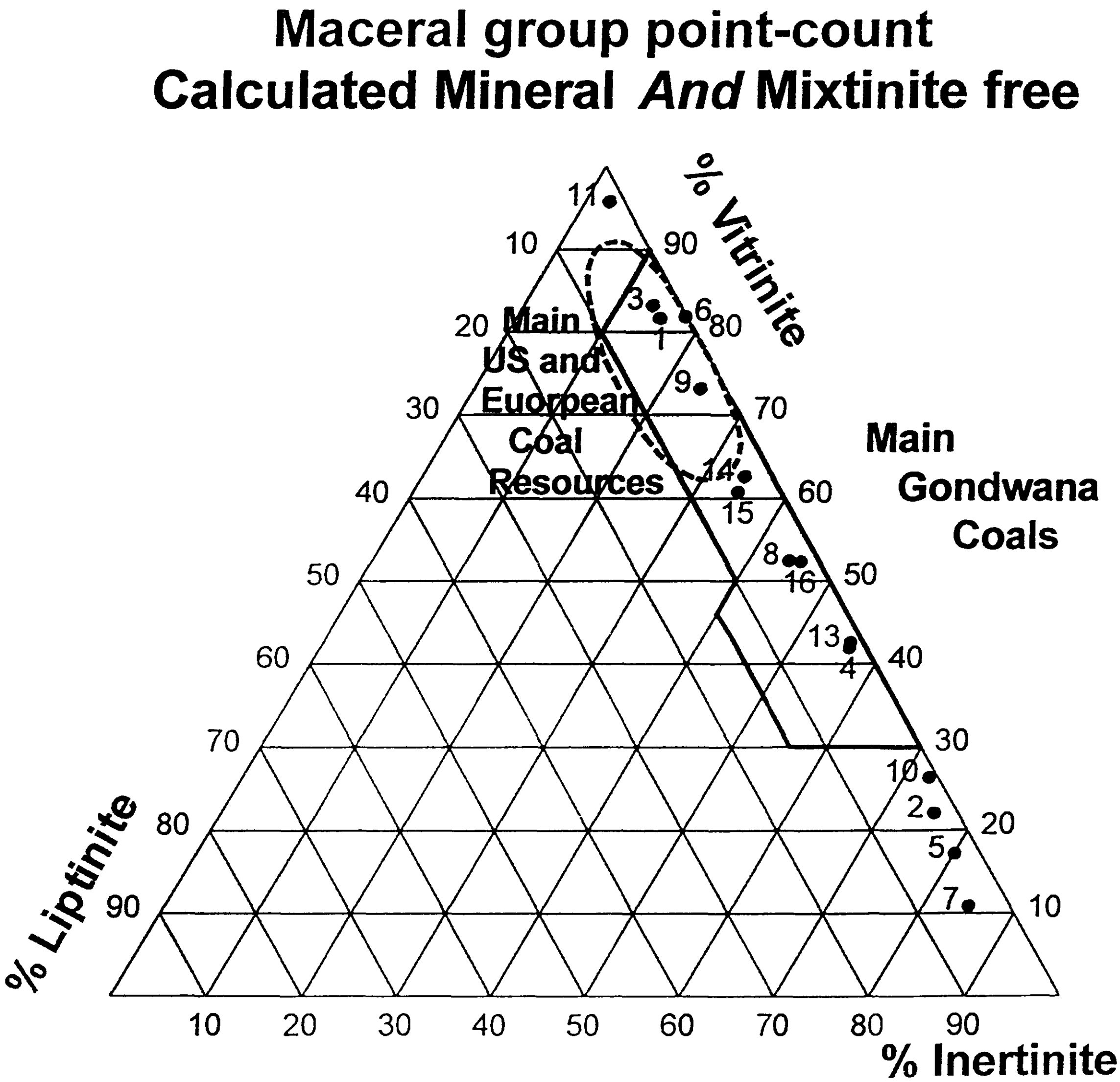

Figure 12. Ternary diagram of maceral group composition (mineral- and mixtinite-free basis) of Kyrgyz coals sampled by the USGS. The field of "main Gondwana coals" (solid line) is from Strauss, et al. (1978) and that of "main U.S. coal resources" is from data by Waddell et al. (1978).

constituents, though their content is not easily connected with type of organic matter. Unlike petrographic determination of the organic type of coal, the chemical determination is complicated by large chemical changes as the coal changes from lignite to higher rank. Hence, normally only chemical ratios and cross relations between parameters can be used to determine organic type. Figure 14, a classical *van Krevelen* diagram, shows the low H/C ratio at a given rank (measured by O/C) of many Kyrgyz coals resulting from their high inertinite content. Figure 15 shows the same low hydrogen content, relative to rank as measured by vitrinite reflectance. Our data on hydrogen does not agree very well with data from the literature on Kyrgyz coals. Figure 16 indicates the linear regression line of the LITERATURE / USGS plot for hydrogen, compared with a 1:1 perfect agreement line. Figure 17 shows the same comparison for elemental carbon, with much better agreement. Note, however, the great spread of values from the literature in both cases. We believe that this spread results mainly from differences in sampling and the natural variation in the coals from a given site, not from analytical discrepancies.

7. Sulfur

Sulfur content of the 15 USGS coal samples ranges from 0.32 percent to 2.53 percent (table 9). There is some agreement between the sulfur in the USGS samples and sulfur reported in the literature (fig.18), but also a striking deviation in coals determined by the USGS to contain relatively high sulfur. It is unlikely that this deviation results from analytical discrepancies. More likely, samples reported in the literature may have been "premium" material from a given mine or seam. Sulfate sulfur ranges from 0.04 percent to 0.15 percent and probably represents the oxidation of pyritic sulfur to ferrous sulfate that took place during the interval of time between sampling of the coal and the analyses of the coal. Alternatively, in some instances there may have been some oxidation of the coal prior to our taking the sample. The sum of the sulfate sulfur and the pyritic sulfur is approximately the same as the amount of organic sulfur in most samples. This agrees with a general rule that in much coals half the sulfur is pyritic and half is organic.

There is no reason to expect the presence of any significant amount of any sulfide mineral in these coals other than pyrite or marcasite (both FeS_2). There is excess iron available in each sample to stoichiometrically combine with the sulfur to make the FeS_2.

Coal utilization within the United States is greatly influenced by federal regulations based on the Clean Air Act of 1970, that set standards for emissions of sulfur dioxide (SO_2) from new steam electricity generating plants. The limit was set at 1.2 pounds of SO_2 per million Btu of heat input. Coals that meet the requirements are referred to as "compliance " coals. Four of the 15 samples collected and analyzed meet the standards for compliance (less than 1.2 pounds SO_2 per million Btu): three are close to being compliance and would produce between 1.2 and 1.3 pounds per million Btu; and the remaining eight samples are non-compliance as we sampled them.

In the United States, there are several ways in which a non-compliance coal could be utilized in a new electricity generating facility. These include blending the higher sulfur coal with a coal of lower sulfur content, cleaning the coal prior to burning to reduce the pyritic sulfur, and removal of the SO_2 from the stack gasses by scrubbing the combustion gasses. Presently there is no means

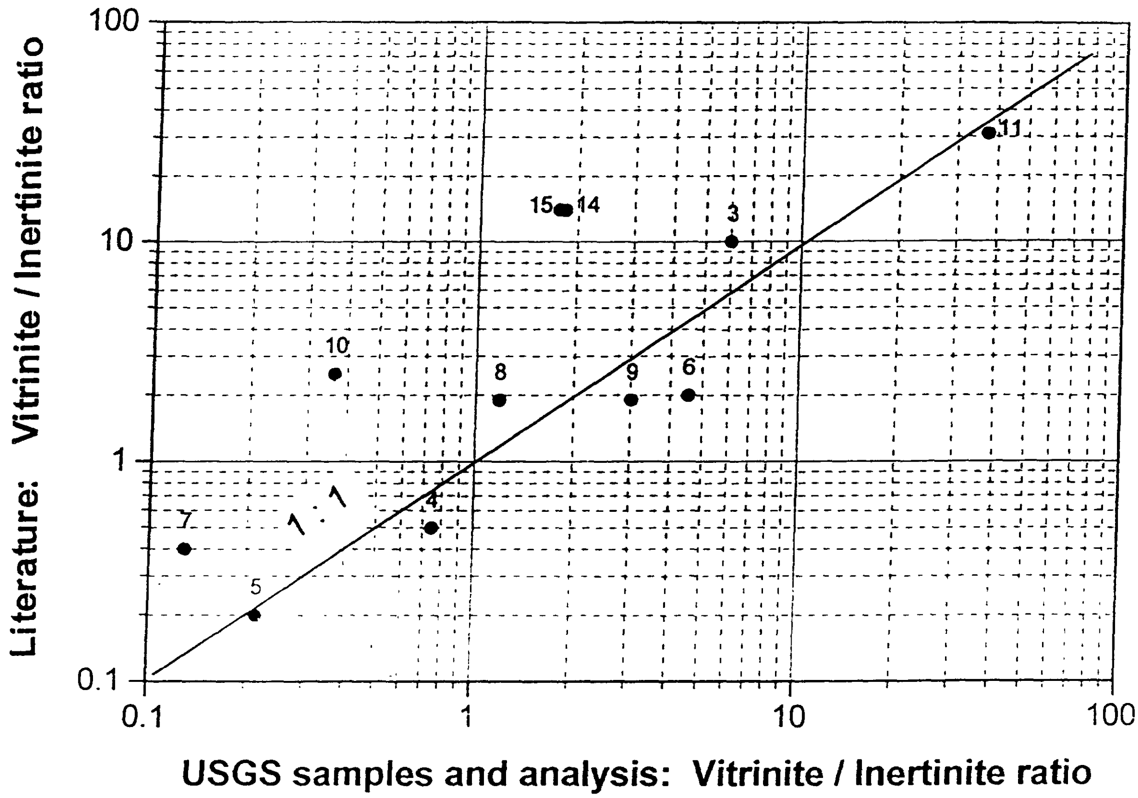

Figure 13. Vitrinite / inertinite ratio of Kyrgyz coals sampled by the USGS in relation to the range of the same ratio reported in the literature for coals from the same mines, in some cases stated to be from the same seam.

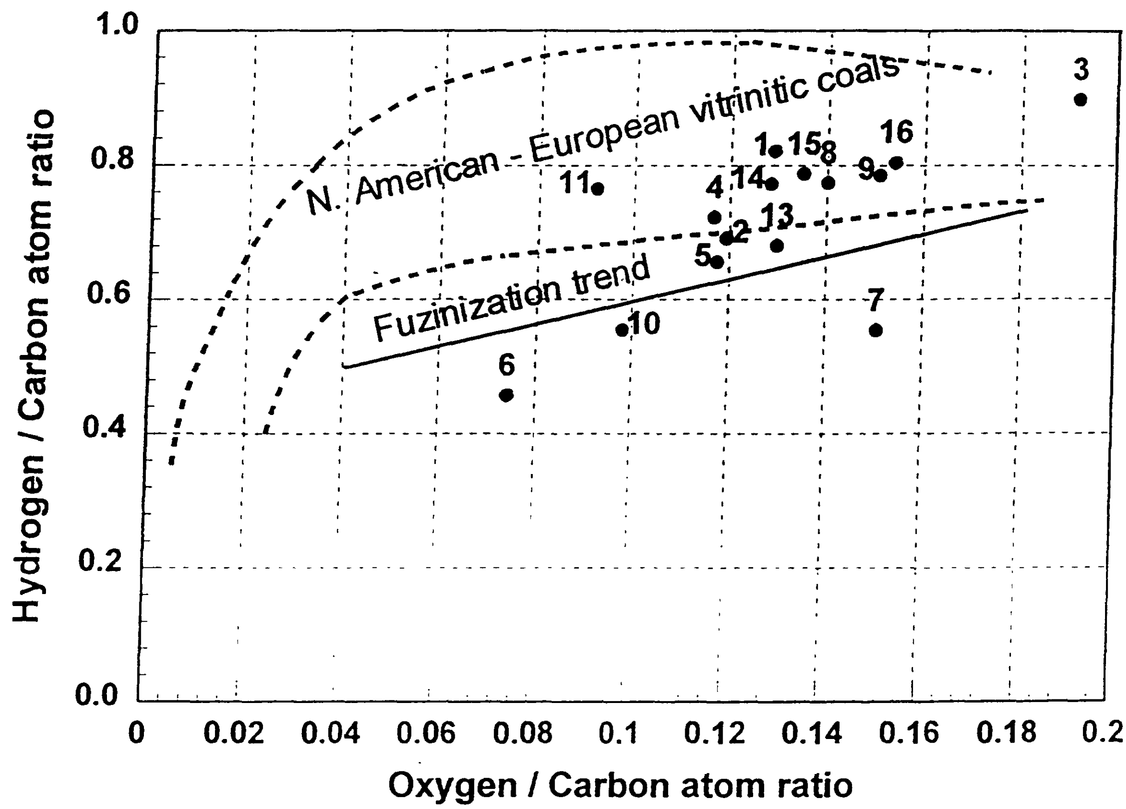

Figure 14. Hydrogen / carbon atomic ratio in relation to oxygen / carbon atomic ratio of Kyrgyz coals sampled by the USGS.

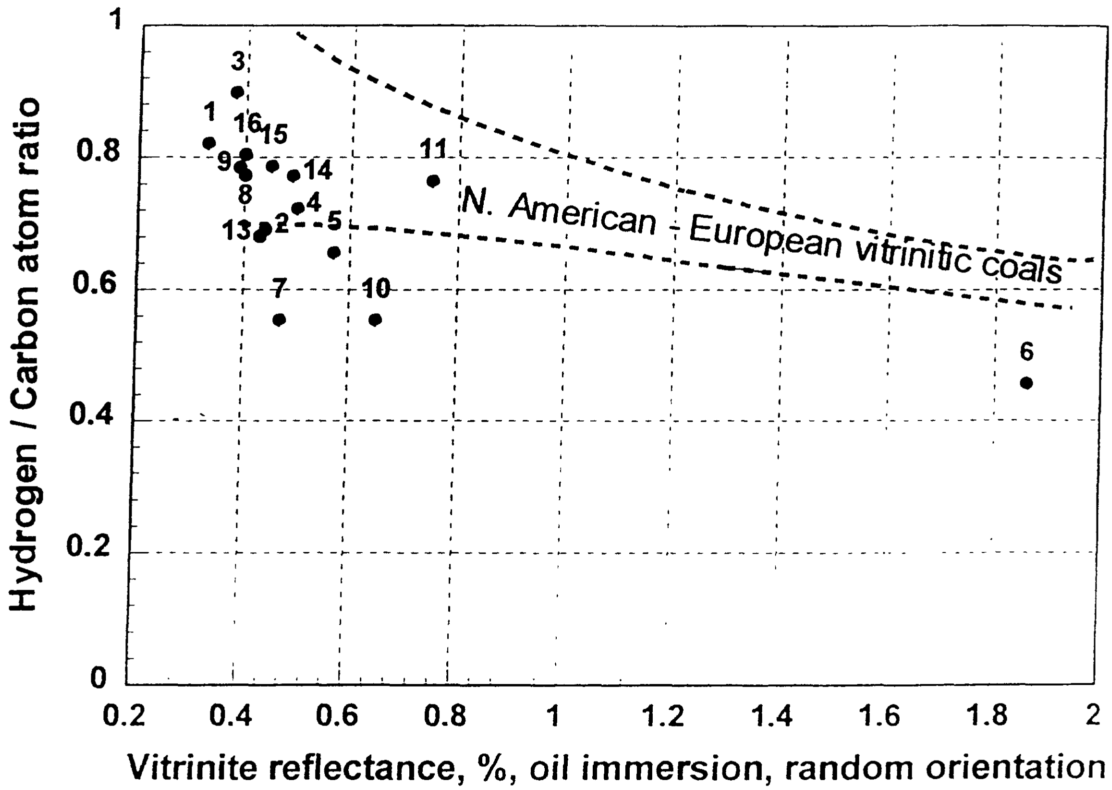

Figure 15. Hydrogen / carbon atomic ratio in relation to vitrinite reflectance of Kyrgyz coals sampled by the USGS.

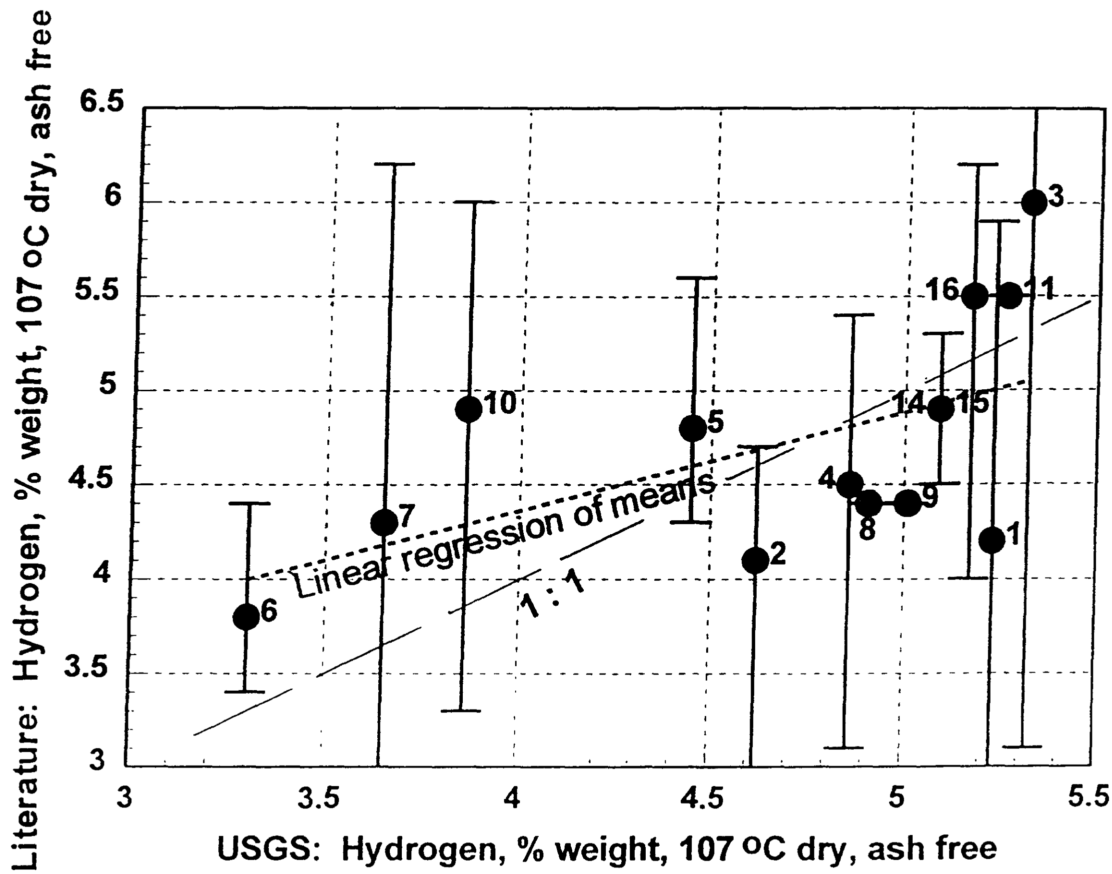

Figure 16. Hydrogen content of Kyrgyz coals sampled by the USGS in relation to the range reported in the literature for coals from the same mines, in some cases stated to be from the same seam.

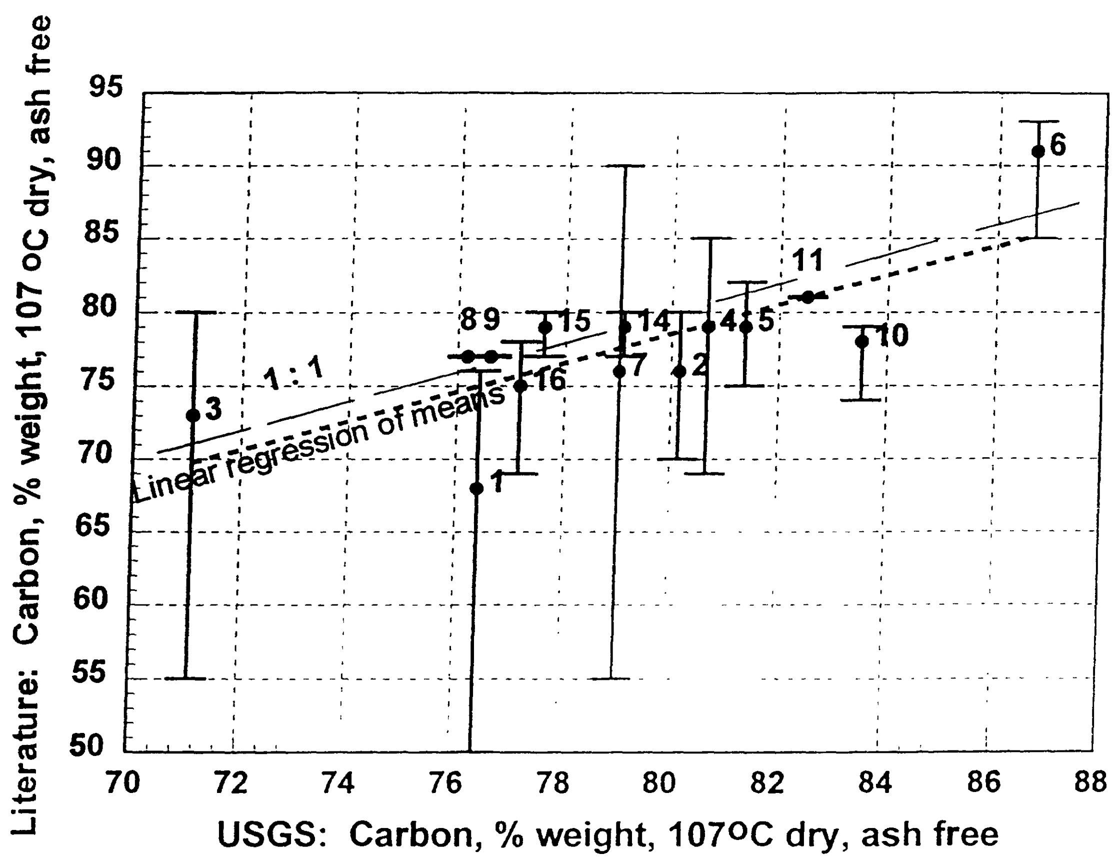

Figure 17. Elemental carbon content of Kyrgyz coals sampled by the USGS in relation to the range reported in the literature for coals from the same mines, in some cases stated to be from the same seam.

Table 9. Total sulfur, % weight, air-dry-coal basis of USGS samples of Kyrgyz coals compared with data from the literature on coals from the same mines, often from the same seams.

Sample Id #	Location Site Name	Seam and Sample Type	USGS S^{tot}_{dry}	Literature S^{tot}_{dry}		
				minimum	maximum	average
K-1	Abshir	? - grab (chunks)	3.56	1.3	7.0	2.6
K-2	AgUlak	6 - run of mine	1.23	0.4	3.0	1.4
K-3	Almalyk	? - chan : top $^1/_3$	2.98	0.2	7.0	1.5
K-4	Dzhergalan	V - chan : top ¼+bot. ½	0.83	0.0	2.0	1.1
K-5	Dzhergalan	IV - channel	0.37	0.0	1.8	0.6
K-6	Kara-Tyube	III - channel (~½)	0.36	0.4	1.1	0.7
K-7	Kara-Keche	Osn. - chan : <$^1/_{10}$	0.55	0.0	2.3	1.0
K-8	Kara-Tut	? - chan : bot. ¼	2.88	0.2	2.8	1.0
K-9	Kara-Tut	? - chan : top $^3/_5$	1.47	0.2	2.8	1.0
K-10	Kok-Yangok	6 - chan : mid. $^4/_5$	0.74	0.0	7.4	1.2
K-11	Kum-Bel	22 - grab	0.84	0.4	1.8	0.8
K-13	Kyzyl-Bulak	? - channel	0.44	0.1	0.3	0.2
K-14	Tash-Kumyr, Severn.	3 - chan : upper	1.02	0.4	7.1	1.1
K-15	Tash-Kumyr, Severn.	3 - chan : lower	1.77	0.4	7.1	1.1
K-16	Valakish	? - chan : mid 3.4m	0.99	0.3	3.7	1.4

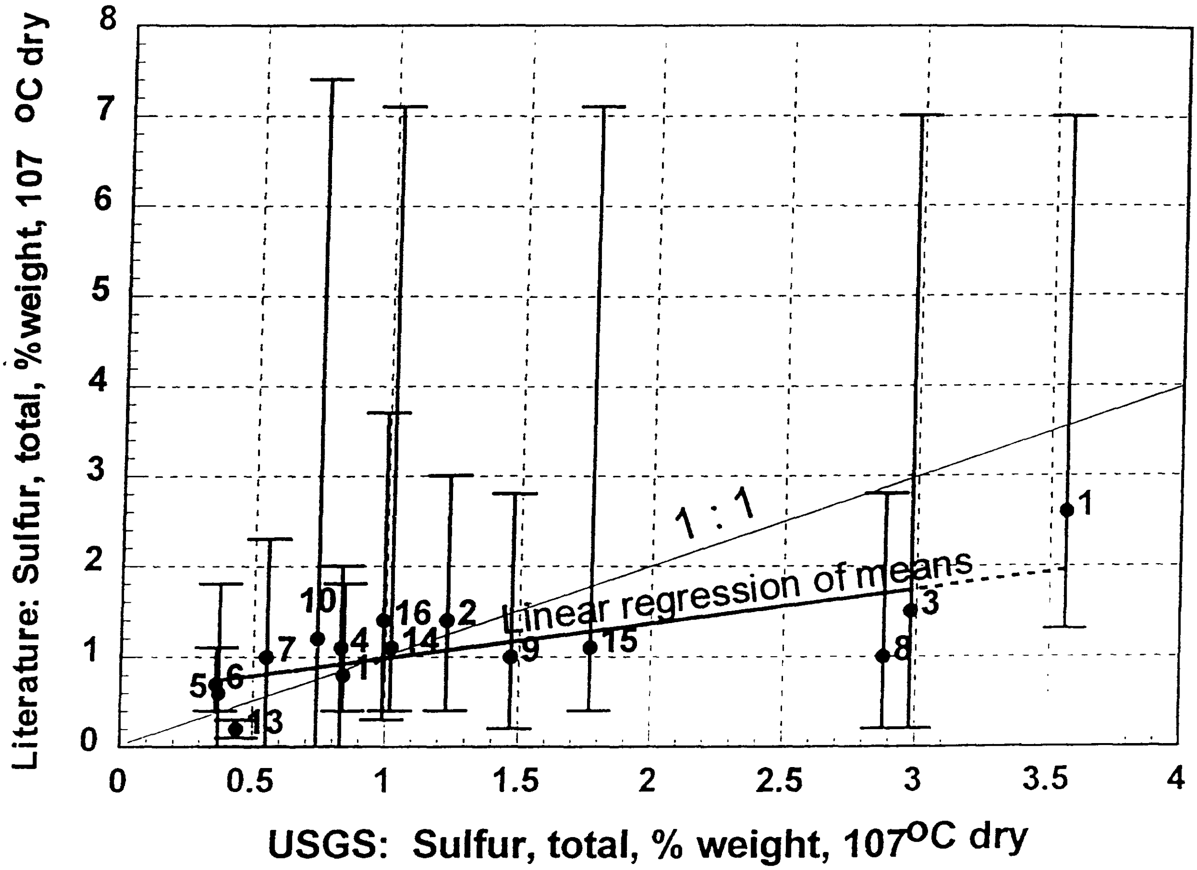

Figure 18. Total sulfur of Kyrgyz coals sampled by the USGS in relation to the range and mean of total sulfur reported in the literature for coals from the same mines, in some cases stated to be from the same seam.

of reducing SO_2 emissions in power and heat stations in Kyrgyzstan to a level comparable to U.S. standards, although the SO_2 emissions are less than in other CIS countries (Mezgin and others, 1993). In 1996 refurbishment of boilers in the main Bishkek thermoelectric plant is scheduled; possibly emissions will be reduced as a result.

8. Major, minor and trace elements (mainly in minerals)

a. Major and minor elements

Mineral matter in coal consists primarily of the following major and minor elements: Si, Al, Fe, Mg, Ca, Na, K, Ti, P, and Mn. We have reported the concentrations of these as oxides of the elements in percentage of the ash of the coal in tables 10 and 11. They are also shown as elements (not oxides) in percent of the total coal sample in tables 12 and 13, later in this chapter.

Coals in which the mineral matter consists principally of alumino-silicate minerals, generally representing the detrital material which had washed into the peat forming environment (swamp), have relatively high SiO_2 and Al_2O_3 contents. Coals that are high in Fe_2O_3 and CaO represent either the deposition of iron and calcium carbonate minerals early in the coal formation process, or the precipitation of these minerals along fractures and bedding following coal formation.

Combustion Engineers have developed several indices with which to classify the tendency of a coal to form bonded deposits on the boiler. These are referred to as fouling indices and generally take the form:

Fouling index= (base/acid) x Na_2O, where base is the sum of CaO, Fe_2O_3, MgO, Na_2O, and K_2O. Acid is the sum of SiO_2, Al_2O_3, and TiO_2.

Using this formula, several of the coals analyzed have fouling indices in the range that might cause concern if the coals were being considered for use in a large pulverized-coal fired steam boiler. However, these measures of fouling are based on experiences with, primarily, bituminous coals of North America, are not precise, and would only indicate the need for further testing of the coals with the higher fouling index values; something that would be done in case of any further major development of coals in the Kyrgyz Republic. In lower rank coals (lignite) the Na_2O content is more heavily weighted when fouling is predicted and only coals with less than 2% Na_2O are considered to be "low fouling".

The limited number of samples reported upon here makes it difficult to generalize concerning the major elements in coals of the Kyrgyz Republic. We do recognize significant variability within a very small area. For example, samples taken only a few tens of meters apart, from two different coal beds at Dzhergalan (samples K4 and K5) exhibit very different ash chemistry. In sample K4 the "base elements" of Fe_2O_3 and CaO are dominant, whereas in K5 the "acid elements" of SiO_2 and Al_2O_3 are dominant.

Sample Id #	Location Site Name	% ash reported in Prox. anal. (750°C) A_{ar}	% ash reported in Prox. anal. (750°C) A_d	% ash reported in first ashing[1]	%LOI Plus % Missing	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO
						% Relative to 100% of reported elements after 2 ashings and one fusion									
K-1	Abshir	4.7	6.6	6.2	34.44	7.90	9.00	54.30	5.86	20.90	1.24	0.26	0.20	0.11	0.24
K-2	AgUlak	11.2	14.6	13.7	16.75	49.61	24.26	10.23	2.46	10.47	< 0.18	1.61	0.91	0.18	0.07
K-3	Almalyk	27.2	35.2	31.1	10.32	49.73	30.78	8.08	1.39	5.78	0.43	0.65	2.73	0.35	0.08
K-4	Dzhergalan	6.6	7.2	8.1	28.12	28.94	14.33	14.75	1.95	37.01	1.27	0.65	0.64	< 0.07	0.40
K-5	Dzhergalan	8.9	9.8	9.6	13.89	52.96	24.04	3.58	0.98	14.52	1.32	1.49	0.92	0.08	0.13
K-6	Kara-Tyube	19.6	22.0	21.9	6.39	61.00	26.28	2.37	2.02	3.06	0.31	3.34	1.52	0.10	0.01
K-7	Kara-Keche	6.8	8.8	8.8	27.16	30.62	24.44	6.53	4.87	31.85	< 0.21	0.22	0.78	0.15	0.33
K-8	Kara-Tut	14.2	18.4	16.0	11.32	51.98	19.96	17.59	1.91	5.46	0.85	1.27	0.81	0.09	0.08
K-9	Kara-Tut	13.3	16.9	17.0	10.65	57.97	22.72	9.00	2.35	4.48	1.02	1.43	0.90	0.09	0.04
K-10	Kok-Yangok	11.6	12.8	13.4	17.38	30.02	15.25	37.04	1.89	13.19	< 0.18	0.38	0.96	0.15	0.96
K-11	Kum-Bel	8.3	8.8	7.9	4.05	54.82	34.71	3.79	1.51	0.52	0.18	3.65	0.71	0.10	0.01
K-13	Kyzyl-Bulak	3.2	3.8	3.5	13.68	50.05	31.74	10.06	0.75	4.78	0.56	0.28	1.32	0.45	< 0.01
K-14	Tash-Kumyr, Severn.	6.8	8.1	8.2	17.66	45.54	21.86	15.42	1.81	9.64	3.32	1.42	0.89	0.07	0.02
K-15	Tash-Kumyr, Severn.	13.1	15.4	14.4	10.47	59.76	20.10	10.24	0.95	4.85	1.47	0.84	1.69	0.09	0.01
K-16	Valakish	8.9	11.5	11.9	28.76	33.27	18.81	7.97	2.30	33.41	0.45	0.63	1.11	1.80	0.25

[1] = For element analysis in Denver, USGS, ashed at 900°C - relative to samples dried at 105°C.

Table 10. Major and minor elements in 900°C high-temperature ash, reported as oxides and normalized so that the sum of these reported oxides is 100%. The percent total ash (105°C dry coal basis) of these analyses is listed along with two columns (as-received and air-dry) of ash values from ashing at 750°C as part of the proximate and ultimate analyses. In table 11 these oxides and some oxide ratios are compared with values taken from the literature on Kyrgyz coals.

Table 11. Six of the major and minor elements in 900°C high-temperature ash, reported as oxides and normalized so that the sum of the ten reported oxides is 100%. Values from the literature on Kyrgyz coal from the same mines, where possible from the same seam, are listed. Two ratios of oxides are listed in order to compare them with values from the literature. In table 10 the full suite of ten oxides and the percent total ash from the coals is listed.

Sample	Location	Chemical analysis in %						
Id	Site	USGS						
#	Name	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O+ K_2O	Al_2O_3 / SiO_2	FeO / Al_2O_3+SiO_2
K-1	Abshir	7.90	9.00	54.30	20.90	1.49	1.14	13.94
K-2	AgUlak	49.61	24.26	10.23	10.47	1.79	0.49	50.03
K-3	Almalyk	49.73	30.78	8.08	5.78	1.08	0.62	50.00
K-4	Dzhergalan	28.94	14.33	14.75	37.01	1.92	0.50	29.97
K-5	Dzhergalan	52.96	24.04	3.58	14.52	2.81	0.45	53.10
K-6	Kara-Tyube	61.00	26.28	2.37	3.06	3.65	0.43	61.09
K-7	Kara-Keche	30.62	24.44	6.53	31.85	0.43	0.80	30.88
K-8	Kara-Tut	51.98	19.96	17.59	5.46	2.12	0.38	52.87
K-9	Kara-Tut	57.97	22.72	9.00	4.48	2.45	0.39	58.37
K-10	Kok-Yangok	30.02	15.25	37.04	13.19	0.56	0.51	32.45
K-11	Kum-Bel	54.82	34.71	3.79	0.52	3.82	0.63	54.93
K-13	Kyzyl-Bulak	50.05	31.74	10.06	4.78	0.83	0.63	50.36
K-14	Tash-Kumyr, Severn.	45.54	21.86	15.42	9.64	4.74	0.48	46.25
K-15	Tash-Kumyr, Severn.	59.76	20.10	10.24	4.85	2.31	0.34	60.27
K-16	Valakish	33.27	18.81	7.97	33.41	1.08	0.57	33.69

Sample	Location	Chemical analysis in %						
Id	Site	Literature						
#	Name	SiO_2	Al_2O_3	Fe_2O_3	CaO	Na_2O+ K_2O	Al_2O_3 / SiO_2	FeO / Al_2O_3+SiO_2
K-1	Abshir							
K-2	AgUlak	48.00	32.00	6.30	7.90	0.00	0.67	48.20
K-3	Almalyk	47.00	29.00	4.90	6.80	1.20	0.62	47.17
K-4	Dzhergalan	46.00	22.00	8.80	13.00	1.90	0.48	46.40
K-5	Dzhergalan	32.00	18.00	22.50	19.00	2.00	0.56	33.25
K-6	Kara-Tyube							
K-7	Kara-Keche	25.00	16.00	8.70	24.80	1.10	0.64	25.54
K-8	Kara-Tut	60.00	20.00	8.10	6.30	1.80	0.33	60.41
K-9	Kara-Tut	60.00	20.00	8.10	6.30	1.80	0.33	60.41
K-10	Kok-Yangok	56.00	22.00	8.90	4.00	0.00	0.39	56.40
K-11	Kum-Bel	58.00	28.00	7.80	1.30	1.30	0.48	58.28
K-13	Kyzyl-Bulak							
K-14	Tash-Kumyr, Severn.	56.00	26.00	6.00	4.00	0.00	0.46	56.23
K-15	Tash-Kumyr, Severn.	56.00	26.00	6.00	4.00	0.00	0.46	56.23
K-16	Valakish	44.00	19.00	9.20	17.00	2.00	0.43	44.48

b. Trace elements

Trace elements determined on the 15 coal samples are shown in tables 12 and 13 and include nearly all elements of environmental and industrial concern. The values were compared with average values for coals of the world, or of the United States for those elements for which world-wide data were not available, and anomalous values were noted. For this purpose, "anomalous" was defined as one tenth or less than the mean or ten times greater than the world-wide mean of the element.

The most significant observation concerning the trace element data is that there is very little that is worth noting about it. There were very few values that were high relative to the world-wide means. They are limited to a single manganese value in a sample from Kok Yangak (K10) and three elevated zinc values (K3, K13, and K14). The mode of occurrence of the Mn is not known and the single high value requires validation. The Mn may be associated with carbonate mineral, but this is only conjecture at this time.

Zinc values are significantly higher than the world coal average in three of the samples. Elevated zinc values generally indicate the presence of sphalerite (ZnS) in coals, and the sphalerite generally occurs along fractures in the coal. Zinc is not considered a problem element in coal inasmuch as it is refractory and remains in the ash when the coal is burned.

Zinc is the only one of the heavy metals to be found in elevated concentrations in the coals sampled for this report. Other elements, which are of interest because of their potential environmental impacts, such as As, Be, Cd, Co, Cr, Ni, P, Pb, and U are all present in amounts similar to or less than the world-wide averages. The relatively low concentrations of Se, Hg, And Cl, which are also potentially deleterious elements, were mentioned previously. The number of samples collected was certainly limited and, although they came from many different coal regions, they can not be considered to represent all of the coals of the Kyrgyz Republic. However the uniformly low trace element concentrations and the very small number of elevated values suggests that trace and minor element concentrations in Kyrgyz coals should not, generally, pose a problem for the continued mining and utilization of the coals.

c. Environmentally significant or volatile elements analyzed in whole coal

In addition to determining the organic elements C, H., O, and N, 45 additional major, minor and trace elements were also determined (tables 12 , 13). Several of those were selected because of their potential deleterious effects on coal utilization or on the environment. These include Cl, Se, and Hg.

The amount of chlorine reported was generally below the lower limit of detection of 0.015% and the highest value reported was 0.089%. Boiler operators are generally not concerned about chlorine in coal unless the value exceeds 0.20%. All of the coals sampled were well below the level at which one would be concerned.

Table 12. Major, minor and trace elements of high-temperature ash (900°C) from USGS samples of Kyrgyz coals. This table lists the data as percent or parts per million of the ash. Whole-coal (dry) values for four volatile elements (Cl, F, Se, Hg) are listed at the bottom. See table 13 for the same data calculated on a whole-coal basis.

Element Name	Units Of Analysis	Sample Id. Number and Location Site Name														
		K-1	K-2	K-3	K-4	K-5	K-6	K-7	K-8	K-9	K-10	K-11	K-13	K-14	K-15	K-16
		Abshir	AgUlak	Almalyk	Dzherg.	Dzherg.	Kara Tyube	Kara Keche	Kara Tut	Kara Tut	Kok Yangok	Kum Bel	Kyzyl Bulak	Tash Kumyr, Severn.	Tash Kumyr, Severn.	Valakish
Major Elements, Analyzed in 900C ash made into 1100C Fusion Pellets (X-Ray Fluorescence)																
Si	%	2.42	19.31	20.85	9.72	21.32	26.69	10.42	21.55	24.21	11.59	24.59	20.19	17.53	25.01	11.08
Al	%	3.12	10.69	14.61	5.45	10.96	13.02	9.42	9.37	10.74	6.67	17.62	14.50	9.53	9.53	7.09
Fe	%	24.90	5.96	5.07	7.41	2.15	1.55	3.33	10.91	5.62	21.40	2.55	6.07	8.88	6.41	3.97
Mg	%	2.32	1.24	0.75	0.84	0.51	1.14	2.14	1.02	1.27	0.94	0.87	0.39	0.90	0.51	0.99
Ca	%	9.79	6.23	3.70	19.01	8.93	2.04	16.58	3.46	2.86	7.79	0.36	2.95	5.67	3.10	17.01
Na	%	0.60	< 0.11	0.29	0.68	0.85	0.22	< 0.11	0.56	0.68	< 0.11	0.13	0.36	2.03	0.98	0.24
K	%	0.14	1.11	0.48	0.39	1.06	2.60	0.13	0.94	1.06	0.26	2.91	0.20	0.97	0.62	0.37
Ti	%	0.08	0.46	1.47	0.28	0.47	0.85	0.34	0.43	0.48	0.47	0.41	0.68	0.44	0.91	0.47
P	%	0.03	0.07	0.14	< 0.02	0.03	0.04	0.05	0.03	0.03	0.05	0.04	0.17	0.03	0.03	0.56
Mn	%	0.12	0.05	0.05	0.22	0.09	0.01	0.19	0.05	0.03	0.61	0.01	< 0.01	0.02	0.01	0.14
Major Elements, Analyzed In 900C Ash (Atomic Absorption)																
Al	%	3.10	10.00	14.00	5.70	11.00	13.00	9.70	9.10	10.00	6.70	17.00	14.00	9.20	9.30	7.50
Ca	%	9.60	6.10	3.70	19.00	9.10	2.30	17.00	3.50	2.90	7.90	0.41	3.10	5.90	3.20	17.00
Fe	%	26.00	5.90	4.80	7.60	2.10	1.50	3.20	11.00	5.60	23.00	2.70	6.10	8.30	6.10	4.00
K	%	0.15	1.10	0.46	0.42	1.00	2.50	0.13	0.89	0.99	0.26	2.80	0.18	0.90	0.59	0.39
Mg	%	2.30	1.20	0.74	0.95	0.51	1.20	2.20	1.00	1.20	0.98	0.85	0.39	0.89	0.50	1.10
Na	%	0.61	0.10	0.30	0.82	0.95	0.21	0.14	0.55	0.69	0.07	0.16	0.07	2.10	0.94	0.30
P	%	0.02	0.05	0.13	0.01	0.02	0.03	0.04	0.02	0.02	0.04	0.04	0.18	0.02	0.02	0.62
Ti	%	0.08	0.40	1.60	0.28	0.40	0.66	0.30	0.36	0.40	0.32	0.44	0.71	0.41	0.86	0.39
Trace Elements, Analyzed In 900C Ash (Atomic Absorption)																
Mn	ppm	1200	450	570	2300	870	89	1900	490	330	6300	110	140	110	87	1400
Ag	ppm	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4
As	ppm	140	< 20	36	< 20	< 20	27	120	130	53	< 20	100	100	110	270	270
Au	ppm	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
B	ppm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ba	ppm	130	130	490	250	280	590	260	460	490	270	1500	220	110	510	250
Be	ppm	11	3	4	16	8	4	2	6	7	6	10	5	27	16	3
Bi	ppm	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Cd	ppm	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	26	< 4
Ce	ppm	38	100	150	120	120	130	57	88	130	76	110	180	86	100	85
Co	ppm	28	14	51	190	72	24	12	29	44	72	100	93	83	48	37
Cr	ppm	120	78	380	97	64	150	46	210	200	110	270	150	250	240	160
Cu	ppm	240	78	260	130	140	170	86	160	200	67	450	160	170	170	190
Eu	ppm	4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	4	< 4	< 4
Ga	ppm	26	25	53	12	23	38	16	34	45	28	56	18	140	51	21
Ge	ppm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ho	ppm	< 8	< 8	< 8	< 8	< 8	< 8	< 8	< 8	< 8	< 8	< 8	< 8	< 8	< 8	< 8
La	ppm	11	63	80	73	79	76	26	50	72	45	57	94	43	59	52
Li	ppm	9	84	98	22	52	120	210	54	75	57	130	94	60	33	37
Mo	ppm	89	< 4	12	< 4	< 4	< 4	27	45	14	< 4	18	9	15	16	8
Nb	ppm	< 8	24	45	14	24	34	18	22	24	11	38	35	24	30	15
Nd	ppm	48	45	70	62	49	57	35	48	76	35	66	94	54	49	35
Ni	ppm	580	41	180	160	130	55	7	100	140	110	240	240	300	220	150
Pb	ppm	24	58	51	96	53	82	47	73	70	27	98	84	84	250	34
Sc	ppm	32	18	59	20	23	32	18	32	43	17	55	36	70	40	27
Sn	ppm	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Sr	ppm	1600	1400	710	360	260	550	4100	820	530	340	65	1300	1600	920	1700
Ta	ppm	< 80	< 80	< 80	< 80	< 80	< 80	< 80	< 80	< 80	< 80	< 80	< 80	< 80	< 80	< 80
Th	ppm	< 8	21	17	20	21	34	23	17	20	18	38	42	21	43	20
U	ppm	< 200	< 200	< 200	< 200	< 200	< 200	< 200	< 200	< 200	< 200	< 200	< 200	< 200	< 200	< 200
V	ppm	160	100	500	81	81	200	41	220	240	120	460	170	390	190	190
W	ppm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Y	ppm	130	38	61	130	63	39	38	81	120	17	100	70	150	110	37
Yb	ppm	10	2	6	16	5	4	3	6	12	< 2	9	5	13	9	4
Zn	ppm	190	130	1100	110	170	250	27	320	120	150	310	11000	430	3100	44
Zr	ppm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Whole Coal Analyses (Various Methods)																
Cl	ppm	< 150	< 150	200	< 150	< 150	890	< 150	< 150	< 150	< 150	410	< 150	360	< 150	< 150
F	ppm	44	85	92	49	59	160	90	88	62	28	100	32	48	50	78
Se	ppm	1.4	0.3	1.2	0.3	0.2	0.4	0.1	0.8	0.6	0.2	0.1	0.4	0.3	0.4	1.0
Hg	ppm	0.26	0.02	0.33	0.02	< 0.02	0.20	< 0.02	0.30	0.23	0.08	0.04	< 0.02	0.14	0.28	0.17
Ash 900C	%	6.2	13.7	31.1	8.1	9.6	21.9	8.8	16.0	17.0	13.4	7.9	3.5	8.2	14.4	11.9

Table 13. Major, minor and trace elements of high-temperature ash (900°C) from USGS samples of Kyrgyz coals, calculated as percent or parts per million of the whole coal, air dry (105°C) basis. Whole-coal (dry) values for four volatile elements (Cl, F, Se, Hg) are listed at the bottom. See table 12 for the same data raw for the ash as analyzed.

Element Name	Units Of Analysis	Sample Id. Number and Location Site Name														
		K-1	K-2	K-3	K-4	K-5	K-6	K-7	K-8	K-9	K-10	K-11	K-13	K-14	K-15	K-16
		Abshir	AgUlak	Almalyk	Dzherg.	Dzherg.	Kara Tyube	Kara Keche	Kara Tut	Kara Tut	Kok Yangok	Kum Bel	Kyzyl Bulak	Tash Kumyr, Severn.	Tash Kumyr, Severn.	Valakish
		Major Elements, Analyzed in 900C ash made into 1100C Fusion Pellets (X-Ray Fluorescence)														
Si	%	0.15	2.64	6.48	0.79	2.05	5.85	0.92	3.45	4.12	1.55	1.94	0.71	1.44	3.60	1.32
Al	%	0.19	1.46	4.54	0.44	1.05	2.85	0.83	1.50	1.83	0.89	1.39	0.51	0.78	1.37	0.84
Fe	%	1.54	0.82	1.58	0.60	0.21	0.34	0.29	1.75	0.96	2.87	0.20	0.21	0.73	0.92	0.47
Mg	%	0.14	0.17	0.23	0.07	0.05	0.25	0.19	0.16	0.22	0.13	0.07	0.01	0.07	0.07	0.12
Ca	%	0.61	0.85	1.15	1.54	0.86	0.45	1.46	0.55	0.49	1.04	0.03	0.10	0.47	0.45	2.02
Na	%	0.04	< 0.02	0.09	0.05	0.08	0.05	< 0.01	0.09	0.11	< 0.01	0.01	0.01	0.17	0.14	0.03
K	%	0.01	0.15	0.15	0.03	0.10	0.57	0.01	0.15	0.18	0.03	0.23	0.01	0.08	0.09	0.04
Ti	%	0.00	0.06	0.46	0.02	0.05	0.19	0.03	0.07	0.08	0.06	0.03	0.02	0.04	0.13	0.06
P	%	0.00	0.01	0.04	< 0.00	0.00	0.01	0.00	0.01	0.01	0.01	0.00	0.01	0.00	0.01	0.07
Mn	%	0.01	0.01	0.02	0.02	0.01	0.00	0.02	0.01	0.01	0.08	0.00	< 0.00	0.00	0.00	0.02
		Major Elements, Analyzed In 900C Ash (Atomic Absorption)														
Al	%	0.19	1.37	4.35	0.46	1.06	2.85	0.85	1.46	1.70	0.90	1.34	0.49	0.75	1.34	0.89
Ca	%	0.60	0.84	1.15	1.54	0.87	0.50	1.50	0.56	0.49	1.06	0.03	0.11	0.48	0.46	2.02
Fe	%	1.61	0.81	1.49	0.62	0.20	0.33	0.28	1.76	0.95	3.08	0.21	0.21	0.68	0.88	0.48
K	%	0.01	0.15	0.14	0.03	0.10	0.55	0.01	0.14	0.17	0.03	0.22	0.01	0.07	0.08	0.05
Mg	%	0.14	0.16	0.23	0.08	0.05	0.26	0.19	0.16	0.20	0.13	0.07	0.01	0.07	0.07	0.13
Na	%	0.04	0.01	0.09	0.07	0.09	0.05	0.01	0.09	0.12	0.01	0.01	0.00	0.17	0.14	0.04
P	%	0.00	0.01	0.04	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.07
Ti	%	0.00	0.05	0.50	0.02	0.04	0.14	0.03	0.06	0.07	0.04	0.03	0.02	0.03	0.12	0.05
		Trace Elements, Analyzed in 900C Ash (Atomic Absorption)														
Mn	ppm	74.4	61.7	177.3	186.3	83.5	19.5	167.2	78.4	56.1	844.2	8.7	4.9	9.0	12.5	166.6
Ag	ppm	< 0.2	< 0.5	< 1.2	< 0.3	< 0.4	< 0.9	< 0.4	< 0.6	< 0.7	< 0.5	< 0.3	< 0.1	< 0.3	< 0.6	< 0.5
As	ppm	8.7	< 2.7	11.2	< 1.6	< 1.9	5.9	10.6	20.8	9.0	< 2.7	7.9	3.5	9.0	38.9	32.1
Au	ppm	< 1.2	< 2.7	< 6.2	< 1.6	< 1.9	< 4.4	< 1.8	< 3.2	< 3.4	< 2.7	< 1.6	< 0.7	< 1.6	< 2.9	< 2.4
B	ppm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ba	ppm	8.1	17.8	152.4	20.3	26.9	129.2	22.9	73.6	83.3	36.2	118.5	7.7	9.0	73.4	29.8
Be	ppm	0.7	0.4	1.2	1.3	0.8	0.9	0.2	1.0	1.2	0.8	0.8	0.2	2.2	2.3	0.4
Bi	ppm	< 1.2	< 2.7	< 6.2	< 1.6	< 1.9	< 4.4	< 1.8	< 3.2	< 3.4	< 2.7	< 1.6	< 0.7	< 1.6	< 2.9	< 2.4
Cd	ppm	< 0.2	< 0.5	< 1.2	< 0.3	< 0.4	< 0.9	< 0.4	< 0.6	< 0.7	< 0.5	< 0.3	< 0.1	< 0.3	3.7	< 0.5
Ce	ppm	2.4	13.7	46.7	9.7	11.5	28.5	5.0	14.1	22.1	10.2	8.7	6.3	7.1	14.4	10.1
Co	ppm	1.7	1.9	15.9	15.4	6.9	5.3	1.1	4.6	7.5	9.6	7.9	3.3	6.8	6.9	4.4
Cr	ppm	7.4	10.7	118.2	7.9	6.1	32.9	4.0	33.6	34.0	14.7	21.3	5.3	20.5	34.6	19.0
Cu	ppm	14.9	10.7	80.9	10.5	13.4	37.2	7.6	25.6	34.0	9.0	35.6	5.6	13.9	24.5	22.6
Eu	ppm	0.2	< 0.5	< 1.2	< 0.3	< 0.4	< 0.9	< 0.4	< 0.6	< 0.7	< 0.5	< 0.3	< 0.1	0.3	< 0.6	< 0.5
Ga	ppm	1.6	3.4	16.5	1.0	2.2	8.3	1.4	5.4	7.7	3.8	4.4	0.6	11.5	7.3	2.5
Ge	ppm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ho	ppm	< 0.5	< 1.1	< 2.5	< 0.6	< 0.8	< 1.8	< 0.7	< 1.3	< 1.4	< 1.1	< 0.6	< 0.3	< 0.7	< 1.2	< 1.0
La	ppm	0.7	8.6	24.9	5.9	7.6	16.6	2.3	8.0	12.2	6.0	4.5	3.3	3.5	8.5	6.2
Li	ppm	0.6	11.5	30.5	1.8	5.0	26.3	18.5	8.6	12.8	7.6	10.3	3.3	4.9	4.8	4.4
Mo	ppm	5.5	< 0.5	3.7	< 0.3	< 0.4	< 0.9	2.4	7.2	2.4	< 0.5	1.4	0.3	1.2	2.3	1.0
Nb	ppm	< 0.5	3.3	14.0	1.1	2.3	7.4	1.6	3.5	4.1	1.5	3.0	1.2	2.0	4.3	1.8
Nd	ppm	3.0	6.2	21.8	5.0	4.7	12.5	3.1	7.7	12.9	4.7	5.2	3.3	4.4	7.1	4.2
Ni	ppm	36.0	5.6	56.0	13.0	12.5	12.0	0.6	16.0	23.8	14.7	19.0	8.4	24.6	31.7	17.9
Pb	ppm	1.5	7.9	15.9	7.8	5.1	18.0	4.1	11.7	11.9	3.6	7.7	2.9	6.9	36.0	4.0
Sc	ppm	2.0	2.5	18.3	1.6	2.2	7.0	1.6	5.1	7.3	2.3	4.3	1.3	5.7	5.8	3.2
Sn	ppm	< 0.6	< 1.4	< 3.1	< 0.8	< 1.0	< 2.2	< 0.9	< 1.6	< 1.7	< 1.3	< 0.8	< 0.4	< 0.8	< 1.4	< 1.2
Sr	ppm	99.2	191.8	220.8	29.2	25.0	120.5	360.8	131.2	90.1	45.6	5.1	45.5	131.2	132.5	202.3
Ta	ppm	< 5.0	< 11.0	< 24.9	< 6.5	< 7.7	< 17.5	< 7.0	< 12.8	< 13.6	< 10.7	< 6.3	< 2.8	< 6.6	< 11.5	< 9.5
Th	ppm	< 0.5	2.9	5.3	1.6	2.0	7.4	2.0	2.7	3.4	2.4	3.0	1.5	1.7	6.2	2.4
U	ppm	< 12.4	< 27.4	< 62.2	< 16.2	< 19.2	< 43.8	< 17.6	< 32.0	< 34.0	< 26.8	< 15.8	< 7.0	< 16.4	< 28.8	< 23.8
V	ppm	9.9	13.7	155.5	6.6	7.8	43.8	3.6	35.2	40.8	16.1	36.3	6.0	32.0	27.4	22.6
W	ppm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Y	ppm	8.1	5.2	19.0	10.5	6.0	8.5	3.3	13.0	20.4	2.3	7.9	2.5	12.3	15.8	4.4
Yb	ppm	0.6	0.3	1.9	1.3	0.5	0.9	0.3	1.0	2.0	< 0.3	0.7	0.2	1.1	1.3	0.5
Zn	ppm	11.8	17.8	342.1	8.9	16.3	54.8	2.4	51.2	20.4	20.1	24.5	385.0	35.3	446.4	5.2
Zr	ppm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Whole Coal Analyses (Various Methods)														
Cl	ppm	< 150	< 150	200	< 150	< 150	890	< 150	< 150	< 150	< 150	410	< 150	360	< 150	< 150
F	ppm	44	85	92	49	59	160	90	88	62	28	100	32	48	50	78
Se	ppm	1.4	0.3	1.2	0.3	0.2	0.4	0.1	0.8	0.6	0.2	0.1	0.4	0.3	0.4	1.0
Hg	ppm	0.26	0.02	0.33	0.02	< 0.02	0.20	< 0.02	0.30	0.23	0.08	0.04	< 0.02	0.14	0.28	0.17
Ash 900C	%	6.2	13.7	31.1	8.1	9.6	21.9	8.8	16.0	17.0	13.4	7.9	3.5	8.2	14.4	11.9

Mercury and selenium are of potential concern in coal combustion because the elements are volatile and, when in significant concentration, are deleterious to animals, including humans. Concentrations of these two elements in the 15 coal samples from the Kyrgyz Republic that we have analyzed are approximately an order of magnitude less than (one-tenth the value) the average concentration of these elements in other coals of the world.

9. Technical character of coals

a. Heating value

The heating value of coals is determined in the laboratory in a bomb calorimeter, but there are many different ways to report the results -- most only roughly indicate the natural coal with moisture and mineral matter as it is actually used. In some countries, such as the US, the results are commonly reported on a moist basis, but with mineral matter calculated to zero. This requires that the samples actually are of such good quality that bed moisture analysis is valid. Figure 19 shows the moist, mineral-free heat value of the bed-moist USGS samples from Kyrgyzstan, in MJ/kg. Most of the data available in the literature on Kyrgyz coals are dry basis, ash free; such values for the USGS samples are shown in figures 20 and 21. Heating value reported previously for Kyrgyz coals ranges widely among samples from a given mine (fig.22), probably because the character of samples was not well defined when collected or when the results were reported. The results from the USGS samples agree roughly in most cases with the mean of values reported from earlier analyses (fig.22).

b. Ash fusion temperature (reducing / oxidizing)

Ash fusion temperatures are used to predict the slagging and fouling character of coals during combustion. Table 14 shows our analyses for coals from Kyrgyzstan, both in reducing and oxidizing conditions of analysis. The four temperatures reported are initial deformation, softening, hemisphere and fluid (flow) temperature. Our data show temperatures in reducing atmosphere slightly lower than in oxidizing atmosphere, which is characteristic of iron-bearing coals. Ash fusion temperature may be useful mainly where coals are stoker fired, not fed pulverized, but we consider they should be available for our suite of samples because our data are probably the only information of familiar type that combustion engineers outside the former USSR would have on Kyrgyz coals.

c. Hardgrove Grindability index

The Hardgrove Grindability index (HGI) is widely used in engineering of coal combustion. The HGI for the USGS samples of Kyrgyz coals are in table 14. A higher HGI generally predicts coals that are more easily pulverized with lower energy cost, of importance in designing coal-fired generators. Perhaps more important, however, in the present Kyrgyz coal industry is the problem of excess fines produced in mining and handling coal. The HGI may be a good predictor of which coals should be mined to maximize chunk products and which to maximize fine products for particular markets. However, to realize that use of the HGI test, one would need maceral analysis,

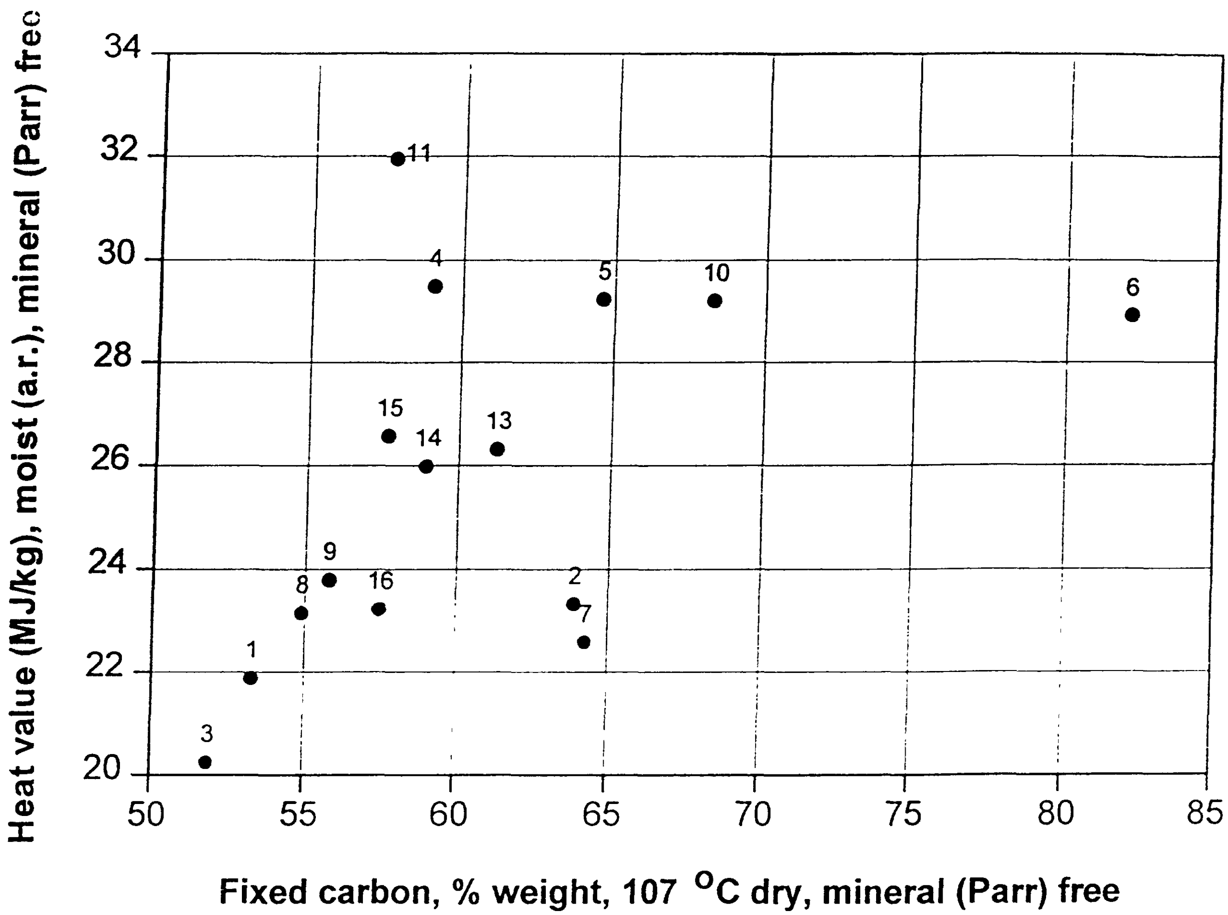

Figure 19. Heat value in relation to fixed carbon of Kyrgyz coals sampled by the USGS.

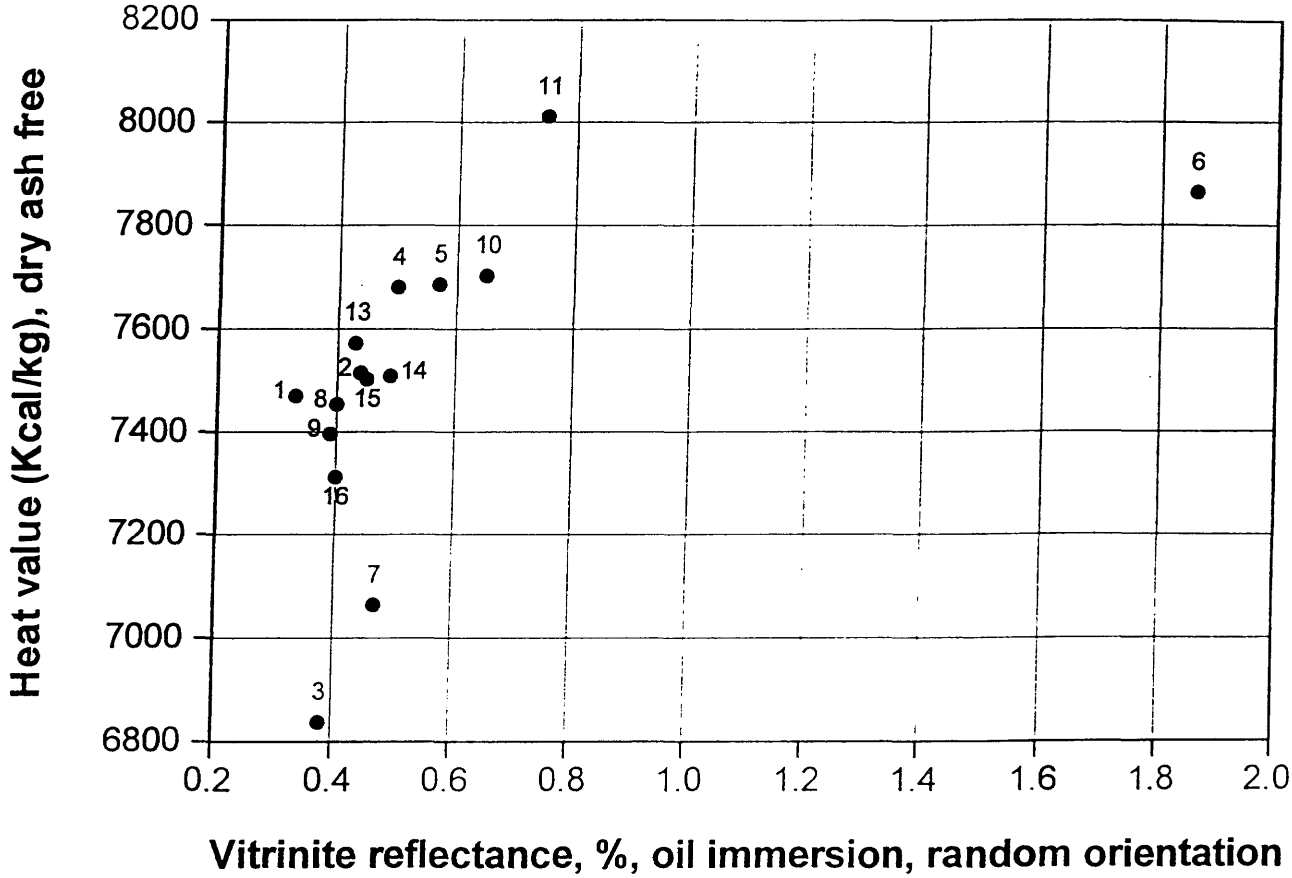

Figure 20. Heat value in relation to vitrinite reflectance of Kyrgyz coals sampled by the USGS.

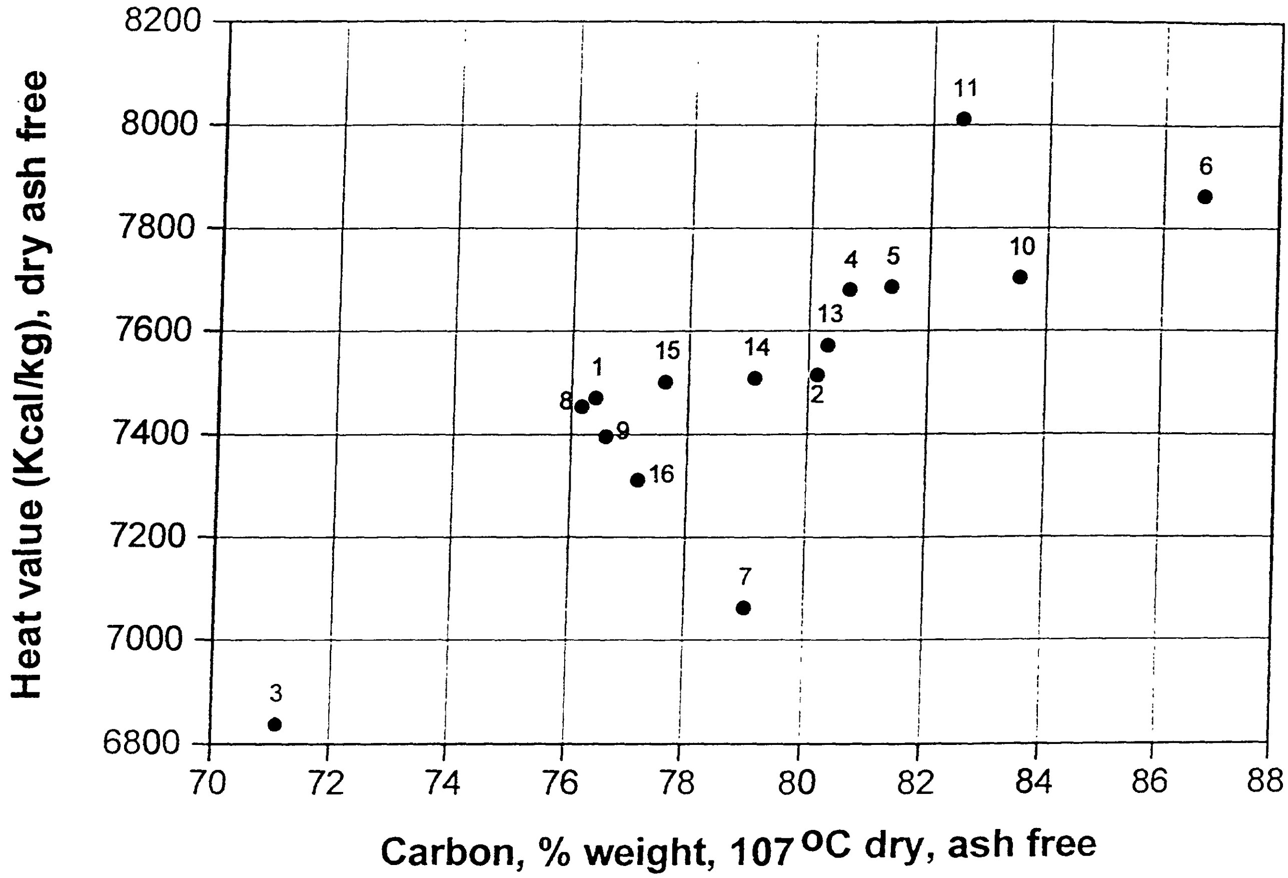

Figure 21. Heat value in relation to elemental carbon of Kyrgyz coals sampled by the USGS.

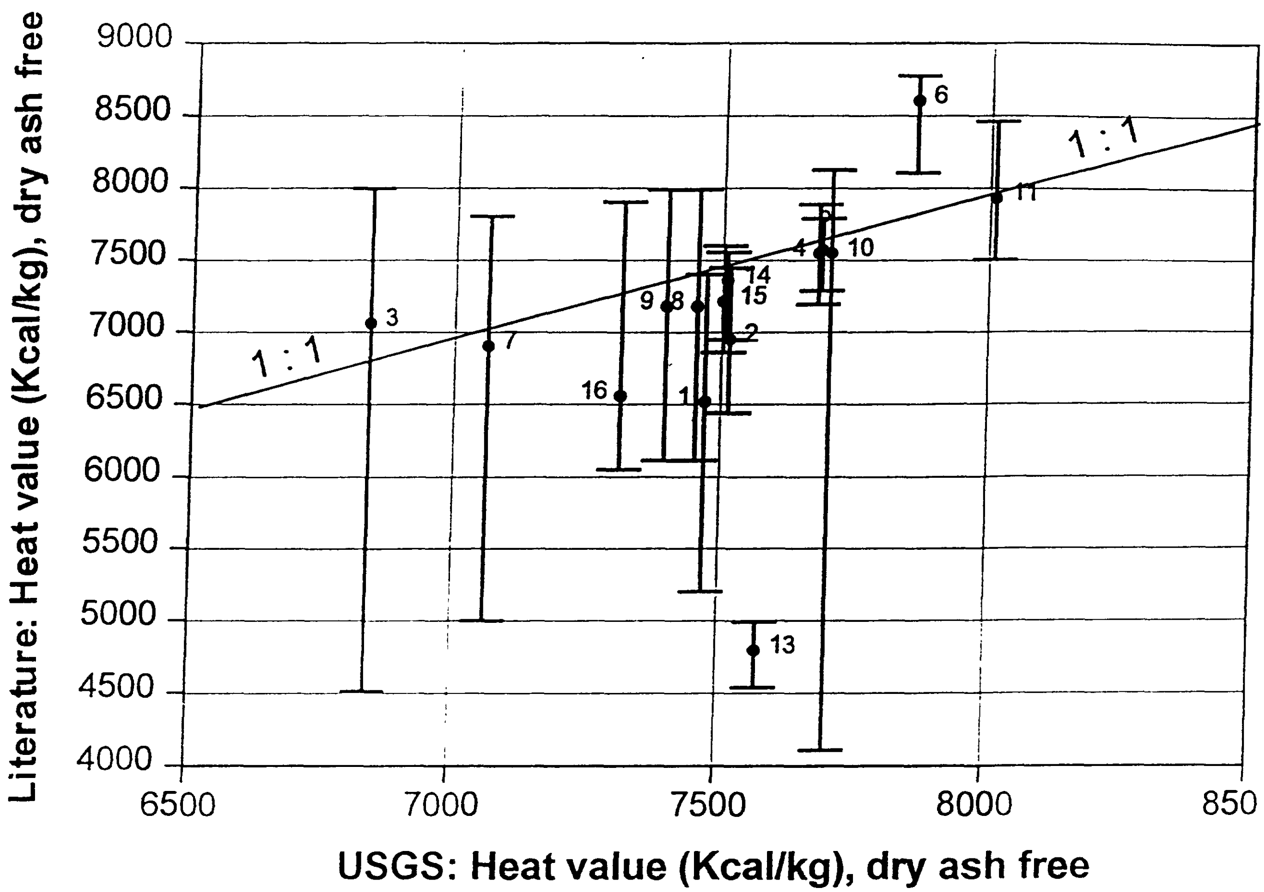

Figure 22. Heat value of Kyrgyz coals sampled by the USGS in relation to the range and mean of heat value reported in the literature for coals from the same mines, in some cases stated to be from the same seam.

Table 14. Ash fusion temperatures in both oxidizing and reducing atmosphere of coal samples collected by the USGS in Kyrgyzstan. Free swelling index, Hardgrove grindability, apparent specific gravity, and ash content (750°C) are listed for the same samples.

K-#	Site	HGI	FSI	S.G.	%Ad	Ash fusion temp. (reducing), °C				Ash fusion temp. (oxidizing), °C			
						Init.Def[1]	Soften.[2]	Hemi[3]	Fluid[4]	Init.Def.	Soften.	Hemi	Fluid
1	Abshir	63	0	1.29	6.6	1232	1249	1254	1260	1293	1310	1343	1421
2	AgUlak	78	0	1.31	15	1227	1266	1282	1310	1282	1310	1332	1360
3	Almalyk	61	0	1.52	35	1343	1416	1438	1482	1427	1449	1477	1504
4	Dzhergalan	48	1	1.35	7.2	1204	1254	1260	1271	1210	1260	1271	1321
5	Dzhergalan	51	0	1.41	9.8	1277	1304	1316	1388	1299	1321	1366	1404
6	Kara-Tyube	93	0	1.53	22	1360	1427	1454	1521	1371	1466	1493	1527
7	Kara-Keche	71	0	1.3	8.8	1321	1343	1354	1360	1332	1349	1360	1377
8	Kara-Tut	73	0	1.35	18	1099	1127	1138	1210	1266	1304	1343	1388
9	Kara-Tut	62	0	1.37	17	1177	1199	1216	1427	1266	1310	1349	1443
10	Kok-Yangak	68	0	1.34	13	1138	1166	1193	1216	1304	1321	1349	1366
11	Kum-Bel	47	4	1.31	8.8	1538	1538	1538	1538	1538	1538	1538	1538
13	Kyzyl-Bulak	73	0	1.29	3.8	1377	1421	1427	1443	1432	1466	1477	1493
14	Tash-Kumyr,S	69	0	1.37	8.1	1093	1121	1132	1199	1238	1254	1271	1293
15	Tash-Kumyr,S	61	0	1.4	15	1154	1177	1193	1210	1282	1338	1366	1399
16	Valakish	73	0	1.33	12	1160	1182	1204	1216	1193	1210	1232	1266

K-#	Site	HGI	FSI	S.G.	%Ad	Ash fusion temp. (reducing), °F				Ash fusion temp. (oxidizing), °F			
						Init.Def.	Soften.	Hemi	Fluid	Init.Def.	Soften.	Hemi	Fluid
1	Abshir	63	0	1.29	6.6	2250	2280	2290	2300	2360	2390	2450	2590
2	AgUlak	78	0	1.31	15	2240	2310	2340	2390	2340	2390	2430	2480
3	Almalyk	61	0	1.52	35	2450	2580	2620	2700	2600	2640	2690	2740

for Unsworth and others (1991) indicate strong influence of maceral composition on coal breakage and on the HGI.

d. Free swelling index

The free swelling index (FSI) is an inexpensive test to predict the swelling and caking properties of coal. In addition, where coals are known to swell or cake normally, low FSI values can indicate weathering *in situ* or in storage, which lowers the value of coal. The use in this present study is very limited, for the coals presently produced in Kyrgyzstan are mostly not caking. Two of the coals sampled could have been expected to cake or agglomerate -- the low-volatile bituminous coal from Kara-Tyube (K-6) and the high-volatile B bituminous coal from Kum-Bel (K-11) (table 5). The latter does have FSI of 4.0 as expected, but the former shows FSI of 0 (tables 4, 14), probably because the rank is too high to maintain caking properties, but possibly because the sample was weathered.

10. Sources of additional similar data on Kyrgyz coals

At the present time the data resulting from this project may be the only information on Kyrgyz coals in forms familiar to engineers and geologists who work in the US and elsewhere outside the former USSR. However, there is much scattered information on Kyrgyz coals in the Russian-language technical literature, though more on geology than technology. Two recent publications on properties and technology of Kyrgyz coals are Barsanayev, S. B., editor, 1991, Improving methods of exploiting coal deposits of Central Asia (mainly physical properties of coal and rock in mining) and Dzhamanbayev, A. S., 1983, Coals of Kyrgyzstan and rational ways of using them (mainly chemical and industrial and briquetting properties).

Additionally there is a very large body of "fond" information and raw data on file at the Ministry of Geology and Mineral Resources in Bishkek. Probably much of that same information is preserved in Tashkent, Uzbekistan (from which much coal work in all of Central Asia was organized) and in Russia -- but access to information on particular coals or sites is likely to be difficult. Both "fond" and published information on properties, geology and resources of Kyrgyz coals have been compiled recently by T.S. Solpuyev, head of the Coal Division of the Ministry of Geology and Mineral Resources of the Republic of Kyrgyzstan (Solpuyev, T.S., 1994). Solpuyev's monumental 420 page compilation is particularly valuable because of his great practical field experience in Kyrgyz coal regions and because it serves to identify many unpublished works on coals of Kyrgyzstan.

E. PAST AND PRESENT PRODUCTION, PRICING LEVEL

1. Past and present production

In 1979, about 4.5 million tonnes of coal were produced in Kyrgyzstan. From 1980 to 1990 the production ranged between 3.5 and 4.0 million tonnes. Since then production has decreased drastically and the production for 1995 was about 455 thousand tonnes. Coal production from 1961 to 1994 is shown on figure 23. The sixty-five year production history of the Kok-Yangak mining area in the East Fergana Coal Region, shown in figure 24, exemplifies the production history of much of the coal industry of Kyrgyzstan.

Many reasons have been offered to explain the precipitous decline in production, and it seems clear that a combination of many factors is responsible. Cited reasons are depletion of reserves, antiquated, worn-out machinery, fuel shortages, reluctance of miners to work unpaid, loss of experienced personnel, loss of markets by extra-national decisions, poor transportation infrastructure, and problems in transition from a centrally-planned union economy to a market-based national economy.

Table 15 shows the actual production, imports and exports of coal for Kyrgyzstan in the years 1990-1992, and the same data as planned for the period 1993-2010. Obviously, the plan is badly askew with present reality of less than one million tonnes of coal produced in 1994. No data was available regarding imports and exports in 1994.

In the first four months of 1996 34,400 tonnes of coal were exported to Uzbekistan, 1,800 tonnes to Tadjikistan, and 2,800 tonnes to Kazakstan. Of this 39,000 tonnes all but 600 tonnes were fine coal that presumably was used in district heating plants. Because currencies are not convertible, the coal was bartered largely for foodstuffs which then are distributed to the coal mine workers in lieu of wages.

2. Present and potential utilization

The bulk of the coal resources of Kyrgyzstan are suited for use as a source of thermal energy. A small part of the resources in the Eastern Fergana Coal Region may possess characteristics allowing use as metallurgical coke for smelting iron and other ores, foundry coke, and as smokeless household fuel. The coals are friable and the product of the operating mines includes a large percentage of fine fragments. The fine fragments are not a major problem if the coal is used in powder-coal fired installations such as large thermal electricity and heat stations. The coarser-grained portion of the mines production is usable in a wider range of applications, from stoker-fed boilers to domestic heating and cooking in a variety of stoves.

Unfortunately, there is little market for the fine-grained coal from the Kyrgyz mines. The coarser coal is in demand for heating installations and domestic use. The mining systems in use in Kyrgyzstan inevitably produce a large amount of fine coal for which there is no demand, along with the coarse coal which is in demand.

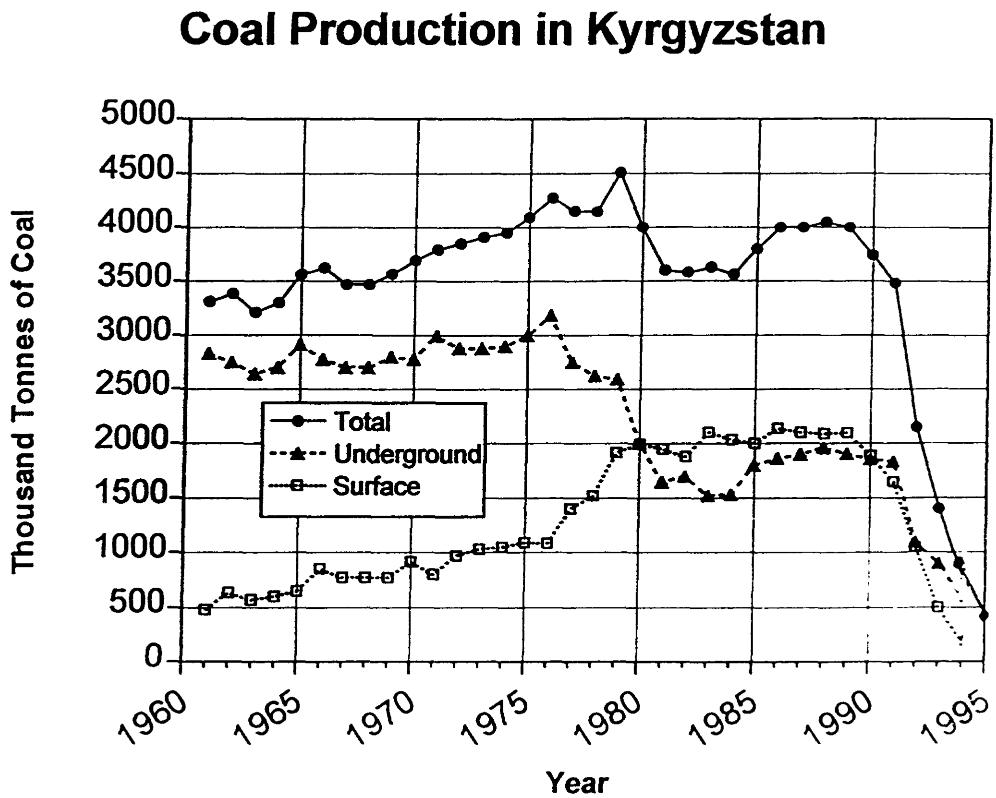

Figure 23. Thirty five year production history of coal in Kyrgyzstan based on KYRGYZKOMUR records, with 1994 production estimated in October 1994 from various sources in the production branch of the coal industry of the country.

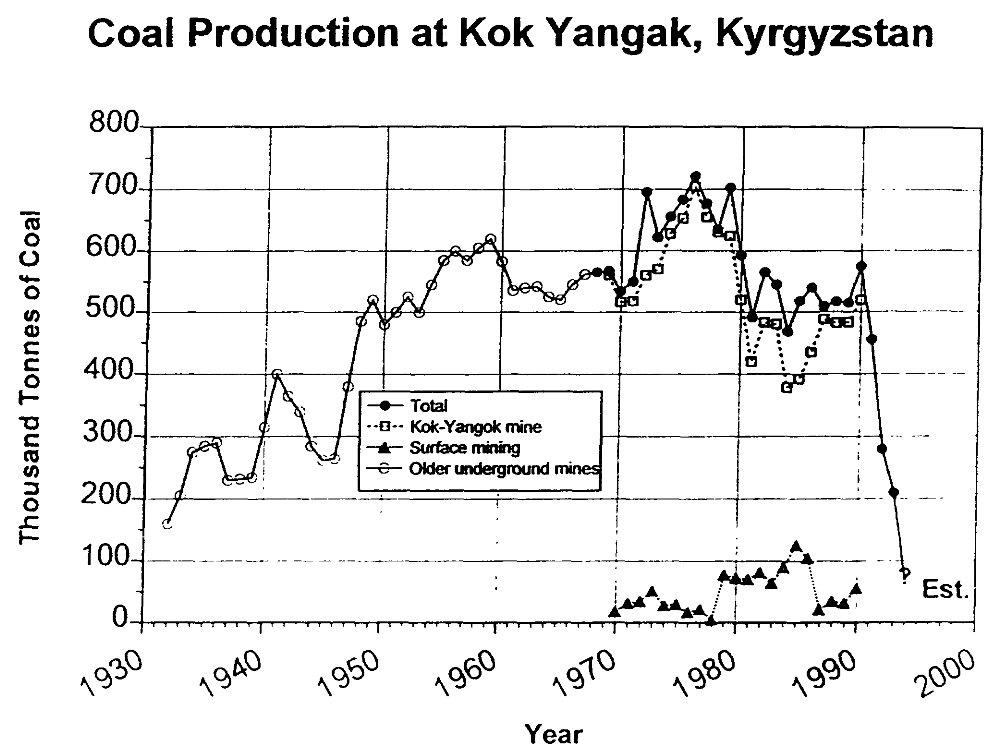

Figure 24. Sixty year production history at Kok-Yangak, Kyrgyzstan. Several entries to underground operations in early decades were replaced by the present horizontal entries in the late '60s. Minor "small enterprise" surface mining presently near Kok-Yangak would not change these production figures noticeably. Based on a plot in KYRGYZKOMUR (1994), pg. 54, and a chart at the mine offices, with 1994 estimated by mine management in October, 1994.

Table 15. Kyrgyzstan coal production, import and export in recent years and plans to 2021.

Parameter			Amount per year, in Thousand Tonnes								
			Actual			Planned					
			1990	1991	1992	1993	1994	1995	2000	2005	2010
1.	Coal production	Total	3742.0	3483.0	2150.5	3300	3600	4200	5300	6300	7000
		Lump quality	1197.4	1105.0	623.6	1045	1060	1196	1834	2268	2514
		Fines and unsorted	2544.6	2396.0	1527.0	2255	2534	3004	3466	4032	4486
2.	Coal import	Total	2900.0	2655.0	1262.9	2000	1900	1500	1000	400	0
		Lump quality	1484.6	1300.0	394.6	1055	1084	1004	666	232	0
		Fines and unsorted	1415.4	1355.0	868.3	945	816	496	334	168	0
3.	Combined resource	Total	6642.0	6156.0	3413.4	5300	5500	5700	6300	6700	7000
		Lump quality	2682.0	2405.0	1018.2	2100	2150	2200	2800	3100	3314
		Fines and unsorted	3960.0	3751.0	2395.2	3200	3350	3400	3500	3600	3686
4.	Use in Kyrgyzstan	Total	4687.4	4418.0	2392.0	4300	4500	4700	5300	5700	6000
		Lump quality	2250.4	2155.0	890.2	2100	2150	2200	2700	3000	3200
		Fines and unsorted	2437.0	2281.0	1501.0	2200	2350	2500	2600	2700	2800
5.	Export	Total	1954.6	1720.0	1024.4	1000	1000	1000	1000	1000	1000
		Lump quality	431.6	250.0	128.0	0	0	0	0	0	0
		Fines and unsorted	1523.0	1470.0	896.4	1000	1000	1000	1000	1000	1000

Though changes in mining methods may reduce the amount (percentage) of fine coal produced, the friability of the coal dictates that there will always be a considerable amount of fines produced along with coarser-sized coal. Development of a use for the fine coal is necessary. Of potential uses for fine coal, the application of briquetting technology to produce cohesive aggregations of the fine coal for use in coarse-coal applications appears most practical and possible.

The coarse coal produced in mining will almost certainly be in demand for the foreseeable future as long as it can be supplied for an affordable price. Small cogeneration facilities using coarse coal to produce heat and electricity in remote areas of the republic could abate present and future energy shortages in those areas if suitable nearby coal deposits are available.

3. Coal pricing structure

a. General

Kyrgyzstan's change to a free market economy during the past four years has disrupted many aspects of business activity. The condition of the general economy of the country can be characterized as distressed and the pricing of commodities is unstable. The information obtained in regard to coal pricing for the purposes of this report reflects these uncertainties. The price is certainly being affected by supply (with factors of quality and location) and by regional demand. However, the overall market can be categorized as being in turmoil due to the following series of factors.

The primary problem is the decline in sale (and hence, mining) of fine size coal with attendant reduction in the availability of coarse sizes. Next, the lack of hard currency payments by heating, electricity generating, and industrial plants to the mines, which could be used to import equipment and supplies, has forced reduction in tonnage mined. In some cases, the market for fine coal was lost when the national government obtained barter agreements across borders, primarily with Kazakstan. In these cases, transportation costs were certainly a factor. Also basic to the problem is the instability of the new currencies of the newly established central Asian countries and hence, the lack of established exchange rates.

As a result, the nation's coal production has declined over a six year period from about 4 million tonnes to 455 thousand tonnes in 1995. The steady loss of market for the fine sizes and non-payment in cash for coal delivered to bulk consumers has forced mines to reduce or cease fine coal shipments and, therefore, maximum production. The resulting decline in availability of funds caused mines to reduce maintenance of equipment, number of miners, support personnel, and staff.

In Kyrgyzstan, the price of coal is affected by the above problems. The price of coal to a consumer anywhere is made up of two main parts: (1) its price at the mine and (2) the price of transportation to its point of use. While a complete coal price analysis is beyond the scope of this study, inquiries made which centered on the coal price at the mine did result in the following information.

b. Price of coal

Kyrgyzstan's historic coal market price is based on the size of coal particles available for sale. The major portion of the market was formerly coal fines defined as 13 mm (1/2") or less. Coal particle sizes over 13 mm are generally considered to be coarse coal which is used primarily for home heating/cooking in less urban areas and is currently in short supply. There are indications that sizes greater than 20 mm (3/4 inch) brings a premium price and is also in short supply nationwide.

COAL PRICES PER METRIC TON FOB MINES/CLEANING-SIZING PLANTS
[in US$ at 10 Som to 1 US$]

FINE COAL (Generally, particle size 13 mm or less):
6 Responses in the $8 - $10 range, average $8.70/ton.
2 Responses: $4/ton and $12/ton.

Note: Price range is due to quality (all are high ash: 20-35%). Fines are being stockpiled at several mines.

COARSE COAL (Generally, particle size more than 13 mm to 20 mm):
6 Responses in the $9 - $13 range, average $9.70/ton.

Note: Quality is about the same as fine coal.

COARSE COAL (Generally, particle size greater than 20 mm, called Lump Coal):
3 Responses at $18.00, $20.00 and $22.50/ton.

Notes: We were told, in the town of Kyzyl Kiya, that premium lump coal sells for $40 - $50/ton delivered. The supply of this coal is very limited and some of the price paid by the consumer will be in the form of bartered vegetables, wood fuel or traded labor.

The BBC television news, aired in Bishkek, interviewed people in the street willing to pay $48/ton (in Kyrgyz Soms) for lump coal delivered for winter heating, if it was available.

The above prices were stated to include cost of production only (direct costs). No indirect costs such as amortization charges for development, equipment and facility depreciation, interest, and other fixed costs are included. The mine that stated a $20/ton price claimed that 18% is profit (the only mine to declare that their price included a profit) and the rest is direct cost of production. This means that coal prices are understated.

In May, 1996, further discussions of prices and taxes elicited the following: the small mines operating under the Private Enterprises Mine Program reach an agreement quarterly with the local government tax office on the value per ton of the coal that they have mined or will mine. This is called the Tax Price. They pay a five percent tax on the coal produced, whether they sell it or not. They then can sell the coal for more or less than the Tax Price. The 5% tax is distributed 20% to local government, 30% to the Oblast, and 50% to the central Government. In addition to the 5% tax on production, they pay 25% tax on sales to the Central Government, 5% insurance (social liability?), 1.5% for road maintenance, and 1.5% to a Water and Air Quality Protection Fund. These taxes must be paid on barter transactions also and the same tax structure applies to all coal mines of the private enterprise program. We do not yet have information about the former state mines, now being converted to state stockholding companies.

In the fourth quarter of 1995, the value of coal produced - the Tax Price - by the Private Enterprises mines ranged from 90 to 120 soms ($9-12) per ton with an average of about 100 soms ($10) per ton. The average for the state-owned mines was about 185 soms ($18.5) per ton and the range was as follows: Kyzyl-Kiya-182 soms per ton, Solyukta-195, Almalyk-142, Agulak (and Kara-Keche?)-96, Tash-Kumyr-173, Kok-Yangak-175, Dzhergalan-242, and Soguty-322. These prices probably are direct cost of production, only. No market (sale) prices were available.

c. Coal Transportation Prices

The price for transportation is as important as the mine price of the coal itself. It is not uncommon for transportation charges to exceed the mine price of coal. In Kyrgyzstan, we were quoted prices of $8 and $10/ton for transporting coal in 7 to 20 ton truckloads. The distances are too vague to consider these prices to be anything but general indicators. We estimate that coal transportation by truck demands a price in the $0.40 to $1.00/ton-mile range. (These prices currently include all, or partly, bartered food stuffs and other agricultural products.) Government subsidy in the form of improved road networks, upgrading and maintenance of existing roads, and an extended internal railroad system will lower the stated high ton per mile transportation costs.

IV. INFORMATION AVAILABILITY

One of the tasks undertaken by the resource assessment team was the gathering of available data pertinent to the coal resource situation in Kyrgyzstan from sources in Kyrgyzstan and the United States. The volume of information that was found is large. The scientific and engineering organizations and agencies of the former Soviet Union produced large quantities of data in a variety of formats and much of that information may still exist. Reportedly, a standardized distribution system was followed for practically all forms of data and information that was recorded on paper. Ordinarily, five copies were prepared of each report, letter, memorandum, etc. One copy went to a central records repository (fond), one to a central ministry or equivalent agency, one to the appropriate agency in the particular Soviet republic, one retained in the originating office or unit, and one kept by the author(s).

Much of the recorded material is fragmentary, such as progress reports, or separated data, such as analyses without sample information. In many cases, perhaps most, comprehensive reports- commonly final- were prepared for particular activities and many of these reports exist as "fond" (repository) literature. The problem is to locate the repository and gain access. Many reports were eventually made available in a published form as summary presentations at domestic and international meetings and much research information is formally preserved in the scientific series and reports of the former Soviet Union. Specialized libraries world-wide contain large quantities of this Russian-language scientific and technical literature. Unfortunately for westerners, much of this literature has not been translated to any other language. Consequently, the data resulting from this study may be the only information on Kyrgyz coals in forms familiar to European and North American geologists and engineers.

The team found that there are large quantities of unpublished information and raw data relevant to the coal resources of Kyrgyzstan in the files of such organizations as the Ministry of Geology and Mineral Resources in Bishkek. Recently, the available information on the geology, resources and characteristics of the coals of Kyrgyzstan have been compiled by T. S. Solpuyev, Head of the Coal Division of the Ministry of Geology and Mineral Resources. His compilation is particularly valuable because it identifies many unpublished works on the coals of Kyrgyzstan. He is presently engaged in preparing much of the data in a form for publication. Published reports that have been particularly helpful are those of Barsanayev (1991) and Dzhamanbayev (1983).

There is a significant amount of available information on the coals of Kyrgyzstan that is beyond the scope of this study; such as tests of pyrolysis behavior and products, mineral transformations at high temperatures, semicoke and coke formation, sorptive properties, tar production and type, briquetting and pelleting tests, extractions with organic solvents, humic acid fractionation, and others. The potential value of such information is difficult to judge, for in the most accessible sources the data are commonly presented isolated from the basic information about the samples. The systematic field and laboratory records from the Soviet Union era do appear to be preserved in large measure - though the loss of institutional memory and access because of retirements, job-switching, emigration, and even the unintentional physical loss or disorganization of records, may be happening at an accelerating rate.

In May, 1996, Bostick visited Tashkent, Uzbekistan, and conferred with S. M. Tomalak, First Deputy Director, and G. M. Ibragimov, Coal Utilization Engineer, of Kumir AB. Kumir AB is the present designation of the organization known as Sredazugol' in Soviet Union times, which was responsible for coal exploration and development in the Central Asian Region. Bostick was told that Kumir AB has "vast" quantities of inherited information about coals throughout the region. There was no opportunity for verification.

The teams efforts in gathering and organizing the available information is largely displayed in the Selected Bibliography to this report, which lists reports both cited and uncited. The bibliography does not attempt to list most fond material or the place of deposit. In the interests of preventing duplication, providing time-related comparative data, and avoiding unnecessary expense and delays, a centralized listing of available information according to type and depository should be created to avoid loss and expedite use in the future.

V. ISSUES AND SUGGESTIONS

The coal resource situation in Kyrgyzstan is affected by the interrelated factors: geologic, extraction, utilization, transportation, economic and institutional/political. The assessment addressed facets of the first four; economics and institutional/political factors are not in the scope of the assessment study except as observations. Environmental factors are commented upon as appropriate.

That the interrelated factors are not merging to satisfy the social and economic needs of the Republic are shown by the demonstrated inability of the existing indigenous coal mining industry to satisfy the anticipated need for coal in the short-term (through 1995) and probably for the long-term (through 2010) also. Efforts to restructure the existing coal industry to retain its viability were obvious by May, 1996.

It was anticipated in 1992 that the energy budget of the Republic in 1994 would require 3.6 million tonnes of domestically-produced coal. Actual production in 1995 was only 455 thousand tonnes.

Long-term energy plans derived in 1992 anticipate that the Republic will need 7.0 million tonnes of domestically-produced coal in 2010.

A. GEOLOGIC FACTORS

Coal is known to be present in more than 60 different named deposits in Kyrgyzstan and the generally-accepted estimate of 31,000 million tonnes of original geologic coal resources in the country may be conservative. The estimate has not changed recently because exploration peaked several decades ago and is almost non-existent now.

1. Issue 1.-Exploration and development

There have been only limited exploration and development efforts in Kyrgyzstan during the past decade or two. Past exploration and development activities have apparently been concentrated in the areas selected decades ago because of location, perceived resource potential, ease of minability, and their place in the long-range energy plans of the former Soviet Union. As a consequence, a large part of the coal resources classed as potentially recoverable are also concentrated in past and present mining areas. The portion of the presently estimated potentially recoverable reserves that has been mined, lost-in-mining or is otherwise unrecoverable, is unknown to the assessment team.

In many of these mining areas the reserves within the technical and economic boundaries of the original mine layout have been depleted without investing in the exploration needed for development of new mines or extensions of the existing mines. In other known coal areas of the country, mining has never been considered, presumably because of remoteness from major utilization sites in the former Soviet Union, difficult or non-existent transportation facilities, and a presumed lack of major resources in easily-minable settings. As previously-remote regions of the nation develop economically and socially, an increase in available energy will be required. An increased understanding of the resources and the potentially recoverable reserves of most of the known coal areas of the nation is required before policy decisions about future energy budgets and plans for capital expenditures for new mines or extensions can be made and justified.

Very limited exploration activities were underway in May, 1996. In the Abshir coal area of the South Fergana region one drill rig was testing expansion of the mining area at the request of the Kyzyl-Kiya mining company. Another drill rig was searching for coal in several areas in the Alay coal region at the behest of residents of the region. In the Uzgen Basin of the East Fergana coal region trenching and other surface exploration activities was being done at the request of small private mine operators. The exploration is being done by the Southern Expedition of the Ministry of Geology and Mineral Resources.

Suggestions are: 1) Increase exploration and development of the nation's coal resources with initial emphasis on present mining areas with recognized resource(reserve) potential, and on areas inadequately explored previously; and 2) Initiate exploration and development activities in parts of the country where coal is known to be present but has never been mined.

2. Issue 2.-Economically recoverable reserves

The coal resources of Kyrgyzstan have traditionally been classified according to reliability (based on the amount and distribution of data) and various technical and engineering factors (such as thickness, depth, rank and others) in a system similar to others used worldwide. It has now been recognized that availability and recoverability evaluations are also required for informed planning of recovery and utilization. Studies of this type meld a great range of geologic, engineering, and technologic factors with economic factors such as mining costs, market demand and product values, to provide the basic information and resulting options needed for planning the extraction and support facilities required for elements of a mining industry, and for overall policy planning.

Suggestion: Evaluate the amount of coal available and economically recoverable in the mining areas of the country. The studies would provide basic data about the coal resources that are recoverable at a cost that the economy of Kyrgyzstan can accept. Studies of this type are required before investment of time, energy and capital in elements of a mining industry can be further justified.

3. Issue 3.-Available information

During the course of past exploration, development, mining, and utilization, large amounts of information were gathered and generated regarding the coal resources of Kyrgyzstan. The information exists in a range of forms and is stored in a variety of settings. Unpublished information in files, such as laboratory analytical reports in laboratories; reports prepared for obscure meetings, published reports in agency or local series, unpublished reports of completed research, and other forms of potentially important data are presently still available in appropriate places. However, reorganizations, retirements, emigration and other causes for loss of institutional memory endanger these types of information that could be of significant future value.

Suggestion: Gather and organize the presently available information that can affect the future coal industry of Kyrgyzstan. As a minimum, the location of such information should be recorded to provide starting points for future recovery attempts. Ideally, the information should be gathered and organized so it could be integrated and interpreted as needs arise. Much duplication might be avoided with considerable future savings in time and money.

B. EXTRACTION FACTORS

1. Issue 4.-Depleted or otherwise inviable mines

Some of the present mining areas of the country have been in operation for long periods, one for at least 100 years. Some of the mines that were developed as large-scale, mechanized, long-wall underground operations several decades ago have depleted their reserves and worn out their machinery, and apparently have no identified adjoining or adjacent potentially recoverable reserves. Some of the older surface mines have reached the limit of safe and technically-feasible mining because of high overburden ratios. Examples of such mines are the Severnay underground mine at Tash-Kumyr in the Northern Fergana Region and the Abshir and Almalyk surface mines in the South Fergana Region.

Suggestions are 1) Encourage mines such as these to produce as much coal as possible for as long as possible with a minimum of capital investment until safety and efficiency require closure; 2) Consider changes in mining methods where this is may be a viable option, for example, from surface to underground as at Almalyk, or developing a surface mine adjacent to an underground mine as at Severnay and Kara-Soo mines in Tash-Kumyr.

2. Issue 5.-Mines suitable for rapid increase in production

Some of the mining areas of the country have mines in operation, development and planning that reportedly have access to large quantities of potentially recoverable reserves. Committal of funds and other resources is required before coal production can begin or increase. The quantity and quality of the available and economically recoverable reserves should be established along with the economic and engineering parameters for successful operations. Examples of such mines and areas are; the Tegenek underground mine presently under development at Tash-Kumyr, and the underground extension of the existing surface mine at Almalyk. Reportedly, the surface operations at Kara-Keche in the Kavak Coal Region could increase production with more, better or different equipment. In addition, underground mining in several areas of the Kavak Region might be feasible if increased production is desired in the future.

Suggestions are 1) Initiate availability and recoverability studies of the mines and mining areas that could contribute to an increase in the country's coal production in a relatively short time-frame; 2) establish the engineering and economic parameters for successful operation of such elements of the future coal mining industry; 3) if production for the benefit of Kyrgyzstan is desirable and feasible, provide the capital investment that will be needed.

3. Issue 6.-Private (formerly Small) Enterprises Mining Program

The modern coal mining industry of Kyrgyzstan was created with the intent of producing large quantities of coal efficiently and safely from large, highly mechanized, underground mines operating with longwall mining methods in areas with access to the transportation network of the former Soviet Union or in areas with nearby utilization sites. The mining areas operated as responsible social entities as well as productive enterprises. All exploration, development, mining, transportation, distribution and marketing were performed at the direction of government agencies. With independence, the loss of traditional markets, and the desire for creation of a nationally-responsive market economy with the energy budget to make it possible, structural changes in the coal industry are occurring.

One of the changes was initiation a few years ago of the Small Enterprises Mining Program, which was designed to satisfy local demand for coal by encouraging mining by local individuals or groups by surface -mining methods at outcrop areas. The mines were restricted to 10,000 or less tonnes of production per year and were required to provide free coal to "Budget Institutes" (schools, hospitals, etc.) who could not pay for the coal. (However, this "free" coal was credited against the taxes they would have to pay on their production.)

In 1995 the Small Enterprises Mining Program was reconstituted as the Private Enterprise Mining Program, restrictions on production and other requirements (such as "free" coal) were removed, and private investment is encouraged. The Small Enterprises received some direction and assistance from KYRGYZKOMUR but the Private Enterprises apparently do not. The Ministry of Geology and Mineral Resources is responsible for resource and reserve information prior to mining, for licensing the private mines, assisting operators with required documentation, providing technical expertise, and monitoring the conduct of mining activities.

At present all of the fifteen licensed private mines (and the dozen or more very small unlicensed mines) are surface operations essentially restricted to outcrop areas and production of coal with available earth-moving equipment. Increased production from the private mines will require more specialized equipment and technical knowledge. One of the possible changes is initiation of small-scale underground mining by conventional or continuous mining methods. Usual advantages of the continuous and conventional mining systems are much less capital expense and production of coal of coarser character. In addition, because they are usually more labor intensive than longwall, continuous and conventional mining might supply employment to considerable numbers of displaced miners. Generally, productivity is not as high; for example, longwall productivity in the USA in 1993 was 3.30 short tonnes per worker-hour, with continuous mining it was 2.84, and with conventional mining it was 2.56. Also, recovery is not as great--in the USA in 1993 it was estimated that 56 percent of the coal in longwall mines will ultimately be recovered, compared with 53 percent of the coal in continuous or conventional mines (Energy Information Admin., 1995).

Suggestion: Increase production to satisfy demand for coal energy, local and otherwise, by assisting the Private (formerly Small) Enterprises Mining Program. The private enterprises mines need training, assistance and support in all aspects of coal exploration, development, mining and marketing so they can be viable members of the developing free-enterprise system in Kyrgyzstan. In addition to up-grading surface mining capabilities, small-scale underground mining with conventional or continuous mining methods should be encouraged. Assistance, direction and overview from the Ministry of Geology and Mineral Resources (and perhaps from KYRGYZKOMUR) within the available experience, responsibilities, and specialities is required. Training and assistance is needed particularly to produce optimum quantities of coarse coal product. The technologic training must be coupled with training and assistance in free-enterprise mining economics, and in the conduct of small market-economy business operations.

C. UTILIZATION FACTORS

1. ISSUE 7.-Briquetting

The coals of Kyrgyzstan are inherently friable. The percentage of the coal produced by the operating mines that is classed as fines varies from about 35 to 70 percent. The longwall underground mines produce the largest percentage of fines and the surface mines produce the smallest percentage. Introduction of other mining methods such as continuous or conventional underground methods might reduce the percentage of fines in the coal produced. However, the friable nature of the coals dictates that, regardless of mining methods employed, the coals produced will include a variable but large portion of fine-sized material. The fine coal is usable in installations burning powdered coal but is poorly suited for use in furnaces with grates that are fed by stokers, or in domestic stoves. At present, the coarse coal portion of the mine production seems to have a ready market but the fine coal does not and must be stockpiled or discarded. Some studies of the possibilities of briquetting the coals of Kyrgyzstan have been conducted. Briquetting programs developed elsewhere to produce briquettes that might be usable in Kyrgyzstan await comparative examination.

Suggestion: Research and test the feasibility of briquetting as a solution to the problem of coal fines. Cooperative consultancy with experts from other countries might accelerate selection of appropriate processes for testing at laboratory and pilot scale.

2. ISSUE 8.-Domestic (non-imported) coal for northern Kyrgyzstan

The heavily populated northern part of Kyrgyzstan in the Chu Valley region depends largely on coal imported from Kazakstan. The quality of the imported coal is mostly poorly- suited for the installations that use it. Reportedly, the mine at Dzhergalan east of Issyk Kul in the northeastern part of Kyrgyzstan could increase production to supply coal for transport by truck or barge to the railroad at Balykchy at the western end of Issyk Kul for transport westward. If this possibility is feasible, the amount of imported coal might be reduced and better quality coal supplied to users in the area. Better quality coal might be blended with imported coal to produce boiler feed of greater efficiency.

Suggestion: Investigate the possibility of increasing coal production at the Dzhergalan mine in the Issyk Kul coal region to supply coal to the Chu Valley Region. The dependency of northern Kyrgyzstan on imported coal might be at least partially alleviated by supplying better-quality domestic coal to the district heating and electricity-generating plants at Bishkek and Kara Balta.

D. TRANSPORTATION FACTORS

1. Issue 9.-Inadequate infrastructure

The pre-independence transportation infrastructure of Kyrgyzstan was never intended to support the internal activities of an independent nation. As a consequence, the Kyrgyz Republic is poorly served by its present roads and railroads. The mountainous character of the country presents serious but not unsurmountable obstacles to building of roads. Maintenance of the existing, heavily-used roads, which total about 30,000 km, is poor, perhaps because of a shortage of operable equipment. [The assessment team saw one operable road grader during their journeys.] Only the northern part of Kyrgyzstan has a railroad system. The areas peripheral to the Fergana Valley in the southwestern part of the country have access to the railroads that serve Uzbekistan, Tadjikistan and Kazakstan. The central, eastern and southern parts of the country have no railroads. A large part of the 370 km of railroads in the nation are in the northern part. For comparison, the farming-ranching State of South Dakota in the USA is about the size of Kyrgyzstan but with far less population, and has 3,100 km of railroads and about 134,000 km of paved and unpaved roads.

Coal mined in the coal regions in southwestern Kyrgyzstan formerly could travel about 1,000 km through Uzbekistan and Kazakstan to reach utilization sites in northern Kyrgyzstan, but presently is restricted to nearby markets. The coal mined in the Kavak coal region in central Kyrgyzstan must be hauled by truck to market areas in southern and northern parts of the country. The coal mined in the northeastern part of the country moves by truck only 65 km to the utilization site.

Suggestions are: 1) Increase routine maintenance of existing roads to improve efficiency and decrease costs of truck transport of bulk commodities such as coal. 2) Develop an expanded railroad transportation system to help solve the problem of transporting domestically-produced coal for use internally, and perhaps for export. The proposed railroad connecting southwestern and northern Kyrgyzstan would allow coal from the southwestern part of the nation to be used in the northern part of the country. In addition, the railroad would traverse the coal-rich Kavak coal region allowing cheaper transportation of the Kavak coals to northern markets.

E. COMBINED FACTORS

1. Issue 10-Periodic Review

The expected improvement in the economy of the Republic will create an increased demand for energy. Demand for coal will increase in correlation with increase in Gross Domestic and National Products. A periodic, preferably annual, review of all aspects of the coal industry of Kyrgyzstan would provide an update and continuing analysis of the progress of exploration, development, mining, marketing and utilization. An annual review by an expert group of country-knowledgeable specialists would be a source of unbiased reliable information for policy-makers, planners and investors. Timely technical and economic information is necessary to support the coal industry in its transition from a part of a centrally-planned monolith to an important and necessary part of a sound market-oriented economy.

Suggestion: Plan an annual review by country-knowledgeable western specialists with appropriate Kyrgyz counterparts and cooperators. The catalytic combination of basic and time-dependent information with the varieties of experience, knowledge and viewpoints represented by the review team and their coworkers would supply the integrated and summarized data needed by a very broad range of governmental and private agencies and organizations. A periodic up-date would be the most cost-effective way to maintain understanding of the swiftly-changing coal energy situation in the Kyrgyz Republic.

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VII. APPENDIXES

APPENDIX I. PRIVATE (SMALL) ENTERPRISE MINING PROGRAM

A. SUMMARY

The Private Enterprises Mining Program allows private investors access to the coal resources of the Republic for the purposes of mining and marketing coal to satisfy local and regional energy requirements of the nation. The private operators engaged in the program receive technical assistance from agencies of the State, primarily from the Ministry of Geology and Mineral Resources, but need additional training and assistance in resource and mining technology, market development, and economics of small, free-enterprise, market-economy mining companies.

B. BACKGROUND

The Small Enterprises Mining Program was initiated by government decree circa 1993 in an attempt to help satisfy the energy requirements of local areas of the Republic. The program envisioned recovery of coal from accessible outcrops by operators with little or no mining experience equipped with whatever earth-moving machinery was available. Operators were required to supply coal to "Budgetary Institutions" (schools, hospitals, etc.) at no cost, and were not allowed to produce more than 10,000 tonnes of coal annually. The Committee of Geology (now the Ministry of Geology and Mineral Resources) provided resource guidance and was responsible for licensing and general overview of operations. The Ministry of Industry, Material Resources and Trade was authorized in September, 1994, and April, 1995, to issue loan guarantees in the amount of 1.5 million soms and 910 thousand soms, respectively, to catalyze the program. Seven enterprises and four enterprises received the loan guarantees, respectively. [*We were told that only two of the eleven firms are repaying the banks that provided the money, the Ministry never had any money for the program, and does not expect to be involved in repayment of the loans to banks.*] Technical advice to the small enterprises was provided upon request by KYRGYZKOMUR, the government coal mining company operating under the Ministry of Industry, Material Resources and Trade.

C. PRESENT STATUS OF THE PROGRAM

Within the past year, the program has been renamed the Private Enterprises Mining Program. The mines now have no production restrictions and are not required to provide unpaid-for coal to the Budget Institutes. KYRGYZKOMUR may still provide advice and assistance, and the ability of the Ministry of Geology to assist the program may have been increased. Table 1 is a list of the licensed Private Enterprises Mines in the program. In addition, there may be as many as eleven unlicensed mines operating in local areas.

Licensed enterprises receive resource and reserve information from the Ministry of Geology and Mineral Resources, and can contract with the Ministry for exploration assistance such as trenching or drilling. The enterprises must pay taxes on production and sales, must submit regular reports on activity, and may receive technical advice and guidance in mining.

TABLE 1.--LIST OF LICENSED PRIVATE ENTERPRISES

ENTERPRISE NAME AND TYPE[1]	LOCATION	Production-1995-tonnes
	Alay Coal Region	
Ken (PF)	Kyzyl-Bulak Area	12,600
Oshpirim (SF)	Kyzyl-Bulak Area	5,000
Kenchi (SE)	Noruskul Area	4,500
	South Fergana Coal Region	
Zhatan (SF)	Yatan-Almalyk Area	300
Gavus (PF)	Chukur Area	?
	East Fergana Coal Region	
Dzhalal-Abad (SE)	Western Kumbel Area	3,900
Soyuz-Ken (PF)	Aldyzhar Area	?
Altybay (VE)	Kumbel Area	5,200
Nichke-Say (SE)	Kumbel Area	1,000
Zhibek (SE)	Ming-Teke Area	200
Tashim (SE?)[2]	Kumbel Area	1,900
	South Central Coal Region	
Sardar (PF) with	Turuk Area	5,900?
Aksay (SE)	Aksay Area	500
	Kavak Coal Region	
Besh-Sary (SE)	Kara-Keche Area	0?
	North Fergana Coal Region	
Seytek (VE)	Kok-Yangak Area	700
	Unknown Region	
Tuyuk (SF)		

[1] PF--Private Firm, SF--Stock Firm, SE--Small Enterprise, VE--Village Enterprise
[2] Not in supplied table of licensed enterprises, but was visited in 1994--see Appendix III.2, Site Visits.

Enterprises are listed in four organizational forms in table 1. It is probable that those listed as Small Enterprises are similar to Private Firms but may still have a more cooperative or communal aspect. Private Firms and Stock Firms are probably similar to western understanding of those terms. Village Enterprises are almost certainly responses to local needs and are cooperative in nature.

Table 1 shows that the bulk of coal produced by the small mines came from the Alay coal region. Reportedly, more coal has been produced than sold in the Alay Region. In other areas sales may have matched production. In addition to the production listed in table 1, about 14,000 tonnes were reportedly produced by about eleven other small mines, perhaps all unlicensed as yet.

At most (all?) of the small mines, coal is 1) mined when someone desiring coal arrives with a truck, or 2) mined and stockpiled awaiting the arrival of someone with a truck. The coal is not segregated by size in most (all?) cases and the percentage of coarse versus fine coal can range widely. Cash is the desired form of payment, barter may be accepted, and humanitarian supply with little or no prospect of recovery of mining costs almost certainly takes place.

The former chief geologist of KYRGYZKOMUR, T. Kydyrbaev, is now an Inspector, headquarted in Osh, who reports directly to the Chief of the Department on Geological Control, Utilization and Conservation of Natural Resources in the Ministry of Geology and Mineral Resources in Bishkek. He has oversight and information responsibility for eleven of the licensed private coal enterprises plus all other mineral extraction operations in Dzhalal-Abad and Osh Oblasts. Private Enterprise activities in other oblasts are the responsibility of the headquarters office in Bishkek.

Each private enterprise must reach an agreement quarterly with the local tax office on the value per ton of the coal mined in that quarter. This value is called the Tax Price and the miner must pay a 5% tax per ton of coal produced based upon the Tax Price. This production tax is distributed 20% to local settlements, 30% to the Oblast, and 50% to the central government. When the coal is sold the actual sale price may be more or less than the Tax Price. On the actual sales price the enterprise operator pays a 25% sales tax, a 5% insurance (social liability?) tax, a 1.5% tax intended for road maintenance, and a 1.5% tax for a Water and Air Quality Protection Fund. [*If coal is traded for other commodities, the same taxes apply to the barter transaction.*]

In the fourth quarter of 1995 the Tax Price established for private enterprises coal mines ranged between 90 and 120 soms per ton and averaged about 100 soms per tonne. In contrast the average Tax Price for state-owned mines was about 185 soms per tonne with a range from 96 to 322 soms per tonne.

In 1995, the private coal mining enterprises reportedly produced almost one-eighth of the coal mined in the Republic. They constitute an important part of the system that supplies energy for the people of Kyrgyzstan. With assistance the private mining companies could supply more of the fuel needs of the Republic, employing citizens to develop and produce indigenous resources.

D. NEEDS FOR PROGRAM DEVELOPMENT

The Small Enterprises Mining Program began as a very legitimate humanitarian response to needs for energy in many local areas of the Republic. In those areas coal was unavailable to, or unaffordable by, some or all of the population. The program still is aimed at satisfying the local and regional energy needs of the people of Kyrgyzstan. However, in common with many other parts of the emerging market-oriented economy of the independent countries that were formerly parts of the Soviet Union, the program is now attempting to emphasize private enterprise as a solution to continuing domestic requirements.

The program was initiated under nearly crisis conditions with essentially no requirements for specialized mining knowledge, experience and equipment. The program assumed that market values and other economic factors were of little importance compared to the fuel needs of the population, and loans (perhaps a form of subsidy) were supplied to start the program.

In its present form the program seems to be in transition from its original strongly communal form to that of privately-funded, small, market-responsive, private enterprises that are intended to support the operators and recompense investment. Some of the enterprises listed in table 1. will never be "privatized". Some of them are attempting to function as "profit-making organizations" or "investment opportunities". Many of them need help of various kinds in their attempt to supply the coal needs of the Republic. Those attempting to become viable economic entities require assistance to increase technological and engineering sophistication, to recognize and satisfy marketing factors, and to understand and apply the complex system of economic and legal factors that affect small-scale, market-oriented, coal-mining enterprises.

Assistance ranging from on-site advice to training could be supplied in response to individual enterprise needs to be identified through the Ministry of Geology and Mineral Resources, other governmental agencies, the Association of Small Enterprises (the members are small mining enterprises operators), or through individual contacts and site visits. In addition, general applicable training courses over an identified range of needs could be offered to groups interested in privatization of small coal mines. One suggestion that emerged during discussions was the desirability of a "planned" or "model" small coal-mining enterprise that could be used as a successful "pilot" analog to instruct, guide and promote private enterprise.

A program to assist and train elements of KYRGYZKUMURHOLDING in mine management, mine planning and design techniques, financial systems, and marketing may be initiated soon. It is appropriate that a similar program designed specifically for private entrepreneurs and investors be available through the Private Enterprise Mining Program.

APPENDIX II

PRODUCTION OF SMOKELESS, WHOLE-COAL BRIQUETS IN THE KYRGYZ REPUBLIC

A. PRELIMINARY ASSESSMENT

B. AN ILLUSTRATIVE CONCEPT FOR AN ENTERPRISE

by

Charles Bliss, Ch.E.

The work reported here is an update of work completed in June 1995 by the author under funding provided by the U.S. Agency for International Development through International Development and Energy Associates, Inc. (IDEA, Inc.) of Washington, DC. Much significant information upon which this report is based results from the work in Kyrgyzstan undertaken by a team from the United States Geological Survey (USGS), plus a coal mining consultant and a coal utilization consultant. This team is referred to in this report as the *Assessment Team*. Nevertheless, the contents of this report are solely the responsibility of the author.

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A -- PRELIMINARY ASSESMENT

INTRODUCTION

Coal mining operations in the Kyrgyz Republic result in large accumulations of fine coal. From information the Assessment Team obtained in the field, this is coal of particle size less than 13 mm (0.51 inches) and perhaps, at times, less than 5 mm (0.20 inches) in size. The data indicate that the coal mine production can contain up to 70% of such unmarketable fines.

Markets in the Kyrgyz Republic for such a product are currently disappearing for various reasons, which are discussed elsewhere in the main USGS report. For example, users of coal, who depend on stoker-fired combustion, find that the fine coals either blow out through the chimney or fall through the grate into the bottom ash before they are adequately burned. Other problems with the use of fine coal occur during transport and storage. Losses of coal occur with accompanying environmental degradation. During the winter the coal fines can freeze on the conveyor belts in storage bunkers. The need for some kind of satisfactory agglomeration (lumping) technology has been recognized by researchers in the country, and their attention has been focused on conventional briquetting technology.

Compressing finely-divided coal into various shapes, suited to their ultimate uses, is a well-known technology (i.e., briquetting) with a long history. Pressure is applied to coal in a mold so that the particles adhere to each other in stable manner for subsequent handling. Some coals can adhere without the addition of a binder material, others cannot. Many different binders have been used or tested: mineral oils and tars, vegetable oils and starches, and absorbent clays such as fuller's earth and bentonite.

Any briquetting on a commercial scale must control environmental pollution and, therefore, must control obnoxious and undesirable emissions during use. Briquetting technology has advanced to the stage where acceptable control of emissions is practical, regardless of the type of use for the briquettes. In other words, the control of emissions can lie in the nature and properties of the product itself, rather than in the manner of use. Moreover, the indications are that such briquettes can be produced at a suitably low cost.

It is the purpose of this report, as an appendix to the report of the Assessment Team, to review and to bring modern developments in environmentally-acceptable, whole-coal-based briquettes to the attention of both the researchers in this field and the concerned government authorities in the Kyrgyz Republic. The briquette manufacturing technology, illustrated in part B of this appemdix, and the estimates of costs are guidance for work which must be done under the technical, economic, and commercial conditions which prevail in the Kyrgyz Republic.

PREVIOUS WORK IN THE KYRGYZ REPUBLIC

The Assessment Team, during its field work in October-November 1994, identified and reported on experimental work done by researchers in the Kyrgyz Republic in recent years. The following summarizes the findings.

In November 1994, a briquetting laboratory existed in Osh in apparently new quarters of the Institute for Integrated Use of Natural Resources (KIPR) of the Academy of Sciences of the Kyrgyz Republic. A brief visit to this facility showed that it is operational with two piston presses and mold heating capability. No information was readily available to assess the capability of this laboratory, or to know the history of its operations. In May 1996, the laboratory had just moved again, and there was no indication what space or facilities would be available for briquetting research. The new (May 1996) address of the laboratory is unknown, and telephones had not been installed. Briquetting research is headed by T. D. Dzholdosheva, but there is some indication that Sh. Kurmankulov will return to the laboratory from a teaching position, if research is resumed.

In 1995, a modified brick press (box chamber, not extrusion) was used to produce about 700 briquettes to test various binders and additives such as clays, lime powders, and cotton processing residue.

In May 1996, in Tashkent (Uzbekistan), the Assessment Team learned that I. G. Baymirov had moved from Osh to do briquetting work at the briquette factory of the Shargun mine in Uzbekistan. Present production there is with petroleum bitumen binder at a cost of about $92 per tonne, but research showed that cheaper (about U.S.$ 78 per tonne) and environmentally better briquettes could be made using cotton processing oil residues.

Published papers in Russian indicate that the goal of the earlier work had been to investigate, under laboratory conditions, the possibility of making briquettes from Kyrgyz brown coal and Kyrgyz bituminous coals with and without binders. These papers also indicate that briquettes with adequate thermal and water stability could be made using residual oils from cotton and animal fat processing in the Fergana Valley.

It has also been indicated that household briquettes could be made from brown-coal fines using bentonite clays or lime if the briquettes were treated with a waterproof coating to provide storage stability.

The Assessment Team identified four papers (in Russian), which report older work on briquetting of Kyrgyz coals. These papers are the following:

Berezkina, Z. H., 1971, *Experiments on processes of making consumer fuel from Kyrgyz coals*, Dissertation in Technological Science, Frunze.

Dzhamanbayev, A. S. and Krichko, A. A., editors, 1978, *Coals of Kyrgyzia and perspectives of increasing their effective use in the economy*, Scientific report IGI, FPI, ICTT, Moscow, 260 p.

Dzhamanbayev, A. S., 1983, *Coals of Kyrgyzia and the means for their rational use*, Frunze.

Kyrmankylov, Sh. Zh., 1990, *Development of briquetting technology for use of Kyrgyz brown coals as domestic fuel*, Dissertation, Technological Science, Dnepropetrovsk.

In addition, the Assessment Team reviewed an unpublished 1993 report by Zh. T. Tekenov of KIPR, Osh. This paper contains a summary of experiments, apparently mostly dealing with organic binders. References to strength, water resistance, and thermal stability probably indicate the ability of the experimental briquettes to maintain their form during handling and shipping, during storage, and during the heating process (in order to maintain the porosity of the bed). A full translation is needed, but some indication of content is the following.

- Petroleum bitumen as the binder gave strong and water stable briquettes with poor thermal stability. Additions of about 20% coking coal from Karaganda (Kazakhstan) increased thermal stability. (Coals similar to Karaganda may be available in the East Fergana coal region of Kyrgyzstan.) Some briquettes were made with Kyzyl-Kiya and Sulyukta coals using a "sodic humate" as binder, but water and thermal stability were low. The stability was increased by thermal treatment (air excluded), but the strength decreased by half.

- Two-stage technology was developed for making briquettes from brown coals. A stage of semi-coking (presumably low-temperature carbonization) is followed by briquetting with a binder using petroleum bitumen or tar from the coking. Other complicated procedures are mentioned, but the complexity increases costs drastically and the procedures use binders that are in net deficit in Kyrgyzstan.

- Trials using regional by-products were made with heavy oil from cottonseed and animal fat processing. "Gudron", a term used locally for seed oil, not petroleum residue, from cottonseed appears to have given good results in terms of briquette quality and binder consumption, after treatment of the gudron with an undefined waste from the Osh textile factory. The research reported included experiments with the parameters surrounding the use of this binder in terms of briquette quality, and a flow chart of a process. The interest seems to have been based on the prospective use of a locally-produced binder.

In Tekenov's 1993 report, a section deals with briquetting using inorganic binders, and refers to the use of bentonitic clays and forms of lime. Bentonite clays occur in the Kyrgyz Republic in association with coal deposits. Almalyk and Sulyukta coals are associated with bentonitic clays and Kara-Kiche and Ak-Ulak coals are associated with both lime (presumably limestone) and local clays.

Comprehension of the significance of the results requires a translation of Tekenov's 1993 report and access to the reports cited above. Nonetheless, the Assessment Team concluded as follows:

- A promising process for the production of briquettes for commercial use in the country appears to be the use of treated extracts from cottonseed oil as the binder. Attractiveness lies partly in the fact that the binder would be a local product from the Kyrgyz Republic or adjacent parts of Uzbekistan.

- The use of bentonitic clays as the binder with or without lime appears to be another promising basis for a commercial process.

- Excessive cost eliminates any consideration of processing to produce briquettes which involves the carbonization (semi-coking) of coal as the first step.

- In all the work reported, nothing is apparent in the discussions concerning the emissions character of the combustion products from the use of the briquettes produced.

CURRENT WORK ON BENTONITE-CLAY BINDER TECHNOLOGY

The potential of an absorbent clay as a binder for the manufacture of a briquette from whole (uncarbonized) coal, which would be smokeless during combustion, appears to have been first recognized in researches at Chulalongkorn University in Bangkok, Thailand, during the 1980s. The findings from this work seem to have been utilized in China. The experiences gained there have been considered by the U.S. Department of Energy in a program funded by USAID for possible application in City of Krakow, Poland, in order to mitigate the environmentally-degrading effects of the use of untreated whole coal for domestic and commercial purposes.

The Bangkok findings were also applied in Pakistan at the Fuels Research Centre (FRC) in Karachi, a unit of the Pakistan Council for Scientific and Industrial Research (PCSIR). The work began about 1987 and is continuing to the present day. The original clay used for the work was fullers earth, but later work focused on the use of bentonite because of superior results in suppressing the emissions of unburned volatile materials from the combustion of the coal. Hydrated lime was incorporated in the recipe for purposes of suppressing the emission of sulfur oxides.
Since most of the Kyrgyz coals do not have as much sulfur as the coals used in the Pakistani briquetting work, the amount of lime to be incorporated in the recipe for a Kyrgyz briquetting industry could be significantly less. However, lime could have a beneficial effect on the ultimate strength of the briquette to withstand handling and shipping. Some potassium nitrate was also incorporated in the recipe in order to promote ease in initial ignition.

The environmental performance of the Pakistani briquettes as a domestic cooking fuel to replace local fuel wood has been measured by the Oak Ridge National Laboratory of the United States Department of Energy. The basis was a comparison in a controlled environment of the emissions of the briquettes with the original coal itself, with fuel wood, with kerosene, and with dung. A perceived major market for the briquettes in Pakistan is as a substitute for scarce fuel wood. Industrial markets are also evident. The experimental work simulated the burning of the fuel under the conditions which exist in rural Pakistan. The conclusion reached was that the bentonite-based briquette would perform environmentally no worse than fuel wood under the conditions of use for cooking in rural housing.

The measurements were made by simulating the conditions during utilization in Pakistan for cooking purposes. The quantitative details and results have been reported in several instances in the literature, namely: Environment International, Vol. 19, pp 133-145, 1993, "*Impact on Indoor Air Quality During Burning of Pakistani Coal Briquettes*"; and a paper presented at the 6th International Conference on Indoor Air Quality, Helsinki, Finland, July 2-4, 1993, "*Comparative Emissions from Pakistani Coals and Traditional Coals*".

The FRC in Pakistan is equipped with a Belgian-wheel briquetting press and the ancillary facilities, which can produce briquettes round the clock at a rate of about eight tonnes per day. Currently the FRC is producing briquettes to serve a local market at a price of Rs. 1400 per tonne, which at the current exchange rate is equivalent to about U.S. $ 45 per tonne. Some interest has existed in Pakistan for the construction of a commercial plant on the scale of 50,000 tonnes per year, but such construction has not materialized as of this date for unknown reasons.

It is possible that briquettes can be produced through extrusion methods, but work on this aspect has not yet been done in Pakistan. The FRC product therefore is pillow-shaped having dimensions of about 5 cm by 5 cm by 2.5 cm thick (2-inches by 2-inches by 1-inch). These dimensions can be varied, depending on the design of the mould machined into the rotating wheels of the briquetting press.

Variations in this technology, which may have occurred in China, is a subject that needs investigation.

The basic principle of the process is the mixing of finely-pulverized whole coal with an absorbent clay such as bentonite. The mechanism which produces the smokeless properties may be theorized as follows.

If the clay during mixing coats each coal particle completely, then, as the coal particle is heated during combustion, the volatile material in the coal is emitted and absorbed by the clay which coats the particle, and retained. As the temperature in the briquette increases, the absorbed materials (primarily carbon and hydrogen compounds of high molecular weight and complex molecular structures) eventually crack, i.e., these absorbed materials break down to carbon and hydrogen compounds of low molecular weight, primarily gaseous in nature, and residual carbon. These cracked products then burn readily and smokelessly. This theory can be supported by the fact that clays are catalysts in petroleum heavy-oil cracking plants, where complex hydrocarbon molecules are broken down into simpler ones.

Sulfur dioxide emissions are controlled through incorporating hydrated lime in the recipe. Sulfur capture by the calcium-hydroxide molecules in the briquette can then reach as high as 65% overall. The bulk of the residual sulfur-dioxide emissions tends to occur at the beginning of combustion, when burning occurs at the surface and there is insufficient contact with the calcium-hydroxide molecules.

The expectation is that each coal candidate for commercial briquetting plant will have to be empirically tested in order to determine the recipe which produces the desired degree of smokelessness during use. The parameters which have to be evaluated during the formulation of such a recipe appear to be the following.

- ***the particle-size distribution in the pulverized coal.***

  If the theory described above is valid, it would appear that the surface to volume relationship of each coal particle will be a critical factor. The reason is that the volume of volatile material that would have to be absorbed by the clay coating the surface will depend on the volume of the coal particle. But the absorbing capability of the clay will depend on two factors, one of which is the amount of surface of the coal particle, the other being the thickness of the clay coating (about which see below).

  As coal particles in the mix become smaller, the volume of the particle decreases as the cube of the diameter while the surface area decreases only as the square of the diameter. The surface to volume ratios are more favorable the smaller the diameter of the particle. It would seem that the smaller the coal particle, the less excess clay may be required in the recipe.

- ***the weight ratio of clay to coal in the mix.***

  Again, based on the theory above, the amount of clay in proportion to the coal will determine the thickness of the clay coating on the coal particle, and hence the clay volume available for the absorption of the volatile material. It would appear, as already noted above, that the finer the coal particle (the greater the surface/volume ratio of the coal particle), the thinner the clay coating and the lower the clay/coal weight ratio. Thus, from a cost point of view, there appears to be a balance to be made in order to minimize the cost of the ingredients in the recipe, between the cost of the clay used in the recipe and the cost of grinding the coal.

- ***the intensity (or thoroughness) of mixing the clay and the coal.***

  It should be obvious that the intensity, or thoroughness, of mixing will determine the extent to which each coal particle is completely covered by clay. This extent is not as important in the center of the briquette, because there will be enough opportunity for absorption as the volatile material travels toward the surface. The extent will, of course, be important for the particles near the surface. In practicality, there is no practical way to control this apparent phenomenon.

- ***the amount of water addition.***

  Water is needed in order to plasticize the mix in preparation for feeding the briquetting press. This water will have to be evaporated later on, after briquetting. The evaporation of the water after briquetting should introduce porosity in the briquette, which should in turn facilitate access for the oxygen in the combustion air into the interior of the briquette. Any excess water causes heat loss; an optimum water content is indicated and this needs to be determined by trial and error.

- ***the amount of lime addition.***

  The primary function of the lime is as a sulfur dioxide absorbent. The amount of lime should be related to the amount of sulfur in the coal, and to the Ca/S molecular ratio for the desired capture. The addition of lime, however, may also have an undetermined effect on increasing the strength of the briquette in terms of downstream handling and transport. Therefore, for a low sulfur coal, the lime content may be determined more by strength considerations than by sulfur suppression needs.

- ***the amount of an oxidant.***

  An oxidant may or may not be needed, probably depending on the volatile material content in the coal. The function of the oxidant is to facilitate the initial ignition of the briquette. A commercial consideration could be the supply of two products, a starting briquette with an oxidant and a standard briquette without an oxidant. The oxidant is usually a small amount of potassium nitrate dissolved in the water used in the recipe.

The Fuels Research Centre in Karachi has accumulated considerable experience in recipe-formulation for a variety of Pakistani coals.

COAL AND BRIQUETTE QUALITY

The Assessment Team collected sixteen samples of Kyrgyz coals for laboratory analysis, one which was lost in shipment. The results of the analyses are reported in the United States Geological Survey Open-File Report titled *Assessment of the Coal Resources of the Kyrgyz Republic.* For convenience, the analytical results of relevance to briquette manufacture and combustion performance are reproduced here.

The samples were analyzed for their proximate analyses, their ultimate analyses, the forms in which sulfur occurs in the coals, and their heating values. The results are reported in the tables listed below. The following box explains the headings in the tables.

		Subscripts	Superscripts
A = Ash	C = Carbon	ar = As received	s = sulfate
W = Moisture	H = Hydrogen	d = Dry	p = pyritic
VM = Volatile Matter	N = Nitrogen	daf= Dry, Ash-free	o = organic
FC = Fixed Carbon	O = Oxygen	eq = Equilibrium Moisture	org = organic
Q = Heating Value	S = Sulfur		t = total
FSI= Free Swelling Index	ID= Sample Number		

Table a-1 identifies the samples by number and the locations where they were obtained. **Table a-2** reports the proximate analyses of the coal samples. **Table a-3** reports the ultimate analyses of the samples and also the forms in which sulfur occurs in the samples. **Table a-4** reports the heating values and the free swelling indices for the samples. Finally, **Table a-5** reports the chemical composition of the ash. Table a-6 contains calculations for the expected heating values for two product briquettes, one from a lignitic (brown coal) and the other from a bituminous coal. These coals may not be necessarily identical with the coals found in the Kyrgyz Republic but which are probably sufficiently close for illustrative purposes. Thus, none of the samples identified in Table a-1 appear to be a brown coal with a moisture content of about 48%. However, sample K-10 appears to approximate closely the bituminous coal in Table a-6.

The significance of Table a-6 is that it points out the reduction in the heating value between the initial coal and the finished briquette because of the addition of inert ingredients, the clay and the lime. Thus, it becomes important in selecting a coal for briquetting to insure that the initial ash content is low. In some cases, it may become attractive to beneficiate the coal beforehand in order to reduce ash content (and most likely sulfur content at the same time, especially the pyritic sulfur, S^p_d in Table a-5).

Another observation is the high lime (CaO) content reported for samples K-1, K-4, K-7, and K-16 in Table a-5. Depending on the original chemical form of the lime in the coal mineral matter and how this content metamorphoses during combustion, the high lime content may serve as a sulfur dioxide absorber and reduce the lime requirement in the formulation of the recipe. The significance of this observation would have to be determined by experimentation.

Finally, it should be noted that the chemical composition of the ash largely determines the ash fusion temperature. Ash fusion temperature could be important in the performance of briquettes in high combustion temperature applications, such as on the grates of stoker-fired furnaces. The criteria for predicting ash fusion and consequent slagging are complex and empirical. A discussion is, therefore, beyond the scope of this Annex.

TABLE a-1
IDENTIFICATION OF COAL SAMPLES TAKEN FOR ANALYSIS

SAMPLE ID NUMBER	LOCATION		
	SITE NAME	LATITUDE (North)	LONGI-TUDE (East)
K-1	Abshir No. 1	40.2	72.4
K-2	Agulak No. 1A+1B	41.7	74.3
K-3	Almalyk	40.3	72.7
K-4	Dhzergalan No. 1	42.5	78.8
K-5	Dhzergalan No. 2	42.5	78.8
K-6	Kara-Dobo	40.8	73.9
K-7	Kara-Keche No. 1A+1B	41.7	74.8
K-8	Kara-Tut No. 2	41.4	72.2
K-9	Kara-Tut No. 1	41.4	72.2
K-10	Kok-Yangok	41.0	73.2
K-11	Kum-Bel	41.0	73.5
K-12	**Lost in Shipment**		
K-13	Sary-Mongol	37.9	72.0
K-14	Tash-Kumyr No. 1	41.3	72.2
K-15	Tash-Kumyr No. 2	41.3	72.2
K-16	Valakish		

TABLE a-2
RESULTS OF PROXIMATE ANALYSES OF COAL SAMPLES

ID	W_{ar}	A_{ar}	VM_{ar}	FC_{ar}	A_d	VM_d	FC_d	VM_{daf}	FC_{daf}	W_{eq}
K-1	28.92	4.69	31.58	34.81	6.61	44.42	48.98	47.56	52.44	27.47
K-2	23.68	11.18	24.28	40.86	14.64	31.81	53.55	27.27	62.73	17.64
K-3	22.83	27.17	25.50	24.50	35.21	33.05	31.74	51.00	49.00	22.54
K-4	8.33	6.61	35.27	49.79	7.21	38.47	54.32	41.46	58.54	7.81
K-5	9.02	8.92	29.58	52.48	9.80	32.51	57.69	36.04	63.96	7.89
K-6	11.19	19.56	13.74	55.51	22.03	15.47	62.50	19.84	80.16	4.85
K-7	22.45	6.83	25.71	45.01	8.81	33.15	58.04	36.36	63.64	18.47
K-8	23.07	14.17	29.27	33.49	18.42	38.05	43.53	46.64	53.36	19.56
K-9	20.96	13.34	29.83	35.87	16.88	37.74	45.38	45.40	54.60	20.14
K-10	9.27	11.64	25.87	53.22	12.83	28.51	58.66	32.71	67.29	7.37
K-11	5.13	8.31	37.13	49.43	8.78	39.14	52.10	42.89	57.11	4.60
K-13	16.76	3.18	31.26	48.80	3.82	37.55	58.63	39.04	60.96	12.81
K-14	16.69	6.81	31.88	44.62	8.18	38.26	53.56	41.67	58.33	16.09
K-15	14.46	13.13	31.52	40.89	15.36	36.85	47.79	43.54	56.46	14.75
K-16	22.54	8.88	29.69	38.89	11.47	38.34	50.19	43.30	56.70	20.24

TABLE a-3
RESULTS OF ULTIMATE ANALYSES OF COAL SAMPLES
(Including Chemical Forms of Sulfur)

ID	ULTIMATE ANALYSIS					FORMS OF SULFUR			
	H_{daf}	C_{daf}	N_{daf}	S^{org}_{daf}	O_{daf}	S^{t}_{d}	S^{p}_{d}	S^{s}_{d}	S^{o}_{d}
K-1	5.23	76.42	1.39	2.27	13.15	3.56	1.34	0.10	2.12
K-2	4.82	80.16	1.02	0.74	12.76	1.23	0.55	0.04	0.64
K-3	5.32	71.00	0.78	2.16	18.20	2.98	1.49	0.10	1.39
K-4	4.86	80.67	1.01	0.26	12.56	0.83	0.56	0.02	0.23
K-5	4.45	81.37	1.02	0.17	12.75	0.37	0.11	0.11	0.15
K-6	3.30	86.71	0.94	0.39	8.59	0.36	0.03	0.02	0.31
K-7	3.65	79.03	0.84	0.34	15.88	0.55	0.19	0.04	0.32
K-8	4.91	76.18	1.15	1.20	14.23	2.88	1.84	0.06	0.98
K-9	5.01	76.61	1.20	1.00	15.41	1.47	0.55	0.09	0.83
K-10	3.86	83.54	0.83	0.21	10.92	0.74	0.49	0.06	0.19
K-11	5.26	82.51	1.17	0.77	10.14	0.84	0.08	0.05	0.71
K-13	4.56	80.33	0.74	0.23	13.91	0.44	0.17	0.05	0.22
K-14	5.09	79.11	1.14	0.51	13.54	1.02	0.54	0.02	0.46
K-15	5.09	77.60	1.24	0.73	13.98	1.77	1.12	0.03	0.62
K-16	5.17	77.17	0.69	0.48	15.85	0.99	0.53	0.03	0.43

TABLE a-4
HEATING VALUE DETERMINATIONS FOR COAL SAMPLES
(Including Free Swelling Index)

ID	HEATING VALUE DETERMINATIONS						FSI
	BTU/lb		Kcal/kg		MJ/kg		
	Q_{ar}	Q_{daf}	Q_{ar}	Q_{daf}	Q_{ar}	Q_{daf}	
K-1	8,927	13,447	4,959	7,471	20.76	31.27	0.0
K-2	8,812	13,527	4,896	7,515	20.49	31.46	0.0
K-3	6,154	12,308	3,419	6,838	14.31	28.62	0.0
K-4	11,759	13,824	6,533	7,680	27.35	32.15	0.5
K-5	11,353	13,834	6,307	7,686	26.40	32.17	0.0
K-6	9,799	14,151	5,444	7,862	22.79	32.91	0.0
K-7	8,991	12,714	4,995	7,063	20.91	29.57	0.0
K-8	8,420	13,417	4,678	7,454	19.58	31.20	0.0
K-9	8,747	13,313	4,859	7,396	20.34	30.96	0.0
K-10	10,966	13,866	6,092	7,703	25.50	32.25	0.0
K-11	12,482	14,420	6,934	8,011	29.03	33.53	4.0
K-13	10,914	13,632	6,063	7,573	25.38	31.70	0.5
K-14	10,340	13,516	5,744	7,509	24.05	31.43	0.0
K-15	9,779	13,506	5,433	7,503	22.74	31.41	0.0
K-16	9,025	13,161	5,014	7,312	20.99	30.61	0.0

TABLE a-5
COMPOSITION OF ASH OF KYRGYZ COALS
(Reported as Metal Oxides relative to 100%)

ID	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO
K-1	7.90	9.00	54.30	5.80	20.90	1.24	0.26	0.20	0.11	0.24
K-2	49.61	24.26	10.23	2.46	10.47	0.16	1.61	0.91	0.18	0.07
K-3	49.73	30.78	8.08	1.39	5.78	0.43	0.65	2.73	0.35	0.08
K-4	28.94	14.33	14.75	1.95	37.01	1.27	0.65	0.64	0.07	0.40
K-5	52.96	24.04	3.58	0.98	14.52	1.32	1.49	0.92	0.08	0.13
K-6	61.00	26.28	2.37	2.02	3.06	0.31	3.34	1.52	0.10	0.01
K-7	30.62	24.44	6.53	4.87	31.85	0.21	0.22	0.78	0.15	0.33
K-8	51.98	19.96	17.59	1.91	5.46	0.85	1.27	0.81	0.09	0.08
K-9	57.97	22.72	9.00	2.35	4.48	1.02	1.43	0.90	0.09	0.04
K-10	30.02	15.25	37.04	1.89	13.19	0.18	0.38	0.96	0.15	0.96
K-11	54.82	34.71	3.79	1.51	0.52	0.18	3.65	0.71	0.10	0.01
K-13	50.05	31.74	10.06	0.75	4.78	0.56	0.28	1.32	0.45	0.01
K-14	45.54	21.86	15.42	1.81	9.64	3.32	1.42	0.89	0.07	0.02
K-15	59.76	20.10	10.24	0.95	4.85	1.47	0.84	1.69	0.09	0.01
K-16	33.27	18.81	7.97	2.30	33.41	0.45	0.63	1.11	1.80	0.25

MARKETING CONSIDERATIONS

The purpose of this section is to provide comments and suggestions that should be helpful in the performance of a briquette marketing assessment. This activity should be the next step after assurance exists that a recipe for briquetting exists and sample product could be made available.

The first consideration should be the environmental acceptance of the briquettes to be offered to the market. The technical discussion above with respect to achieving a smokeless performance during combustion should make it reasonable to assume that briquettes ultimately produced from excess coal fines will have such an acceptance.

The environmental work performed under conditions simulating domestic cooking practices in the rural areas of Pakistan, where the common source of energy is fuel wood, has already been reported above. The work employed local stoves. No attention was given to evaluating environmental performance for prospective markets in space heating, which should be of interest in the Kyrgyz Republic, or in industrial uses. However, the indications are that emissions of carcinogenous smoke and sulfur oxides should be no different.

Two industrial uses for smokeless, whole-coal briquettes are worthy of consideration. The first is in brick making and the other can be of particular importance in improving the environmental and thermal performances of the stoker-fired furnace equipment in the Kyrgyz Republic.

With respect to brick making kilns, the Scientific and Technological Corporation of Pakistan (STEDEC), a unit of the Pakistan Council for Scientific and Industrial Research, in 1989 undertook a market study for its briquettes in the areas of brick manufacture (a major labor-intensive industry in Pakistan), space heating for poultry farms, institutional users such as community kitchens and laundries, and domestic users.

One useful set of findings emerged from the STEDEC work. This is shown in Table a-7. Two kilns were fired simultaneously, one with untreated coal and the other with coal briquettes. Significant improvement in the emissions, impact on the operating personnel, and reduction in fuel consumption are indicated. However, a financial analysis of the results of this brick making operation could have established a premium for the briquettes over the price of coal, but such an analysis was not reported.

TABLE a-6
ESTIMATES FOR HEATING VALUE OF SMOKELESS, BRIQUETTED COAL
(Major Assumptions are Noted)

ITEM	LIGNITE	BITUMINOUS
1. Coal Analysis, wt. %		
Moisture	48.0	10.0
Ash	15.0	16.0
Sulfur	1.0	1.0
Heating Value, KgCal/Kg	1,900	6,000
Heating Value. Btu/lb	3,420	10,800
2. During coal preparation, high-pressure pneumatic grinding could reduce inherent moisture in lignite as much as 75%. No moisture reduction for bituminous coal. New analyses would be Component, wt. %		
Moisture	18.8	10.0
Ash	23.4	16.0
Sulfur	1.6	1.0
Heating Value, KgCal/Kg	2,969	6,000
Heating Value. Btu/lb	5,344	10,800
3. If, for sulfur suppression, lime is incorporated in the raw mix in a 2:1 Ca:S molar ratio, new analyses would be Component, wt. %		
Moisture	17.7	9.5
Ash	27.7	19.9
Sulfur	1.5	1.0
Heating Value, KgCal/Kg	2,801	5,725
Heating Value. Btu/lb	5,042	10,305
4. If, for smokeless combustion, 15% by weight of absorbent clay is added to the raw mix, final briquette analyses would be		
Component, wt. % Moisture	15.4	8.3
Ash	37.1	30.3
Sulfur	1.0	0.8
Heating Value, KgCal/Kg	2,436	4,978
Heating Value. Btu/lb	4,384	8,961
Heating Value, KgCal/Tonne	2,436,000	4,978,000
Heating Value, Btu/ton	8,768,000	17,922,000

An analogous market in the Kyrgyz Republic might be the replacement in stoker-fired steam generators of the current coal by the briquettes. The findings of the Assessment Team with respect to existing practices regarding stoker-fired equipment in the Kyrgyz Republic, reported elsewhere in this document, could be useful to summarize here.

The Assessment Team observed during its field work that the utilization efficiency of coal currently being consumed is unusually low. The basic reason is inadequate burnout of carbon from the residual ash. The Team observed residual carbon content in ash up to 40%. The expectation is that this residual content should fall usually below 1%.

The effects of high carbon fly-ash, other than high utilization cost, are unnecessarily high costs for the district heat and

TABLE a-7
COMPARISON OF RESULTS FOR BRICK KILNS
(Untreated Coal vs. Coal Briquettes)

ITEM	KILN NO. 1 Untreated Coal Firing	KILN NO. 2 Coal Briquette Firing
1	Feeding of coal required every 15 minutes	Feeding of coal briquettes required every 40 minutes.
2	Temperature fluctuated between 900°C and 1100°C	Temperature remained constant at 1000°C
3	Larger number of brick rejects due to uneven temperatures.	Very small number of rejects due to more even temperatures.
4	Very large emission of dust, grit and smoke and fumes of sulfur dioxide. Workers had to cover their faces with thick cloth in order to protect them-selves	Emissions of dust, grit, smoke, and sulfur fumes was extremely low and workers could work comfortably without covering their faces.
5	Causes heavy environmental pollution.	Pollution caused is low and acceptable under the circumstances.

electricity production, reduced effectiveness of the ash collection equipment, and greater airborne emissions with potential carcinogenic properties. Also, a high carbon content renders the ash unusable for by-product purposes. Much of this high carbon content may arise from the friable nature of the coal being burned. Fine unburned coal particles can form during the combustion process and be entrained into the gases leaving for the chimney, before the entrained coal is completely burned.

This problem of incomplete burning of coal has been worked on locally already in Kyrgyzstan at the heat plant in Kara-Kol (Issyk-Kol Oblast). A stoker-fired boiler was modified to reduce the carbon content in the ash from 40% to 15%. The accomplishment is impressive, but further reduction in the residual carbon content is still needed. The goal should be residual carbon content less than 1%. The savings in coal consumption from bringing the carbon content of the residual ash down from either 40% or 15% could be large and worth a concerted effort.

The effort could involve an alternative means to achieve a goal of high thermal efficiency for stoker-fired furnaces by the use of a tailored briquette as the stoker feed, instead of friable lump coal. The experience summarized in Table a-7 suggests that something similar could occur if comparable tests were made at the Kara-Kol heat plant, based on their improved operations, between the usual coal supply and a supply of smokeless whole-coal briquettes.

The expectation may be that (1) carbon burnout could be reduced to below 1%; (2) the presence of lime in the briquette could reduce sulfur dioxide emissions materially; (3) the briquette structure could be maintained during its traverse of the stoker grate, which would, in turn, reduce the amount of fly ash to be collected; (4) less fly ash could be deposited on the tubes of the boiler, thereby increasing the heat recovery from the combustion gases and increasing the thermal efficiency of the boiler; and (5) possibly, with a hotter grate and a less opaque atmosphere in the furnace, radiant heat transfer in the furnace could increase thereby further increasing the thermal efficiency of the boiler.

If such a test were to be run, part of the effort should be the determination of the premium on coal prices that briquettes should earn because of superior performance. The result could be compared with the cost of briquette manufacture in order to assess the profitability of such a market. In effect, if the test results support, the price which the consumer is willing to pay for briquettes over the price for coal, should be attractively less than the savings in his operating costs. At the same time, the price should be high enough to enable the manufacturer to produce briquettes at the required level of profitability.

Briquettes for the purpose of testing the hypothesis above, could be manufactured in the facilities at Osh. It may be necessary to acquire a Belgian-wheel briquetting press with spare rolls to enable determination of the optimum physical size and shape of the briquettes, or the volume in the briquettes. The volume may have to fit the residence time of the briquette on the grate to assure carbon burnout to the level desired.

A successful conclusion to a briquette marketing effort could lead to the prospect that much of the fine coal production from the mines would have a market through briquette manufacture.

OBSTACLES

Perhaps the three major obstacles to a successful introduction of a briquetting industry in the Kyrgyz Republic are (a) lack of adequate market knowledge for introducing briquettes; (b) the existence of barter; and (c) the existence of subsidies particularly on the pricing of electricity. These obstacles up to now outweigh the positive aspects that (a) a clay-based, smokeless, whole-coal briquette manufacturing technology exists and has been demonstrated and (b) available knowledge of the quality of a wide range of Kyrgyz coals indicate that suitable recipe can be found for briquette manufacture, and (c) the economic value of the fine-coal stockpiles in the Republic is zero.

Barter discourages investment in the development, construction, operation, and maintenance of industrial facilities. Subsidy of electricity prices such that consumer prices are an order of magnitude below world prices, and laxity in the collection of bills for electricity consumption, make it impossible for an alternative fuel to compete in a free market. Meanwhile, the elimination of subsidy must be a gradual process to avoid hardship on the population.

On the other hand, nothing needs to stop efforts to obtain a better knowledge of the potential market for briquettes in the Kyrgyz Republic.

SUGGESTIONS

Given the will to pursue and evaluate the potential of briquetting, it appears that the institutional means to undertake the efforts could be through expansion of the scope of the Small Enterprise Coal Mining Program. The attention of the participants in this program could be focused on the existing fine-coal stockpiles while existing government policy to support this program could be modified to accommodate the increased scope.

In the event further investigation becomes justified and further details are desired concerning briquetting technology and capital investment and cost data, contact should be made with the author, care of Moseley, Bliss International Associates, Inc., 3133 Creswell Drive, Falls Church, VA 22044-1703, USA; Telephone: 703-241-1757; Fax/Voice Mail: 703-241-8689; Internet: cbliss1@mcimail.com

PRODUCTION OF SMOKELESS, WHOLE-COAL BRIQUETS IN THE KYRGYZ REPUBLIC

B -- AN ILLUSTRATIVE CONCEPT FOR AN ENTERPRISE

INTRODUCTION

The purpose of this addendum is to present a concept for a commercially-sized briquet manufacturing enterprise to provide guidance and relevant information which could be useful when the commercialization of briquet manufacture in the Kyrgyz Republic is considered. The expectation is that such an enterprise would be in the private sector.

The numerical data used below are illustrative and, therefore, not indicative of prospective costs of briquet manufacture in Kyrgyzstan. Labor and equipment costs in the Kyrgyz Republic can be considerably different. The numerical data actually are illustrative of costs in the United States at a coastal location on the Gulf of Mexico.

Nevertheless, an important and critical cost factor in the production of briquets is the cost of the presently stockpiled coal fines. The cost of this coal could range from only the costs of digging the fine coal from the stockpile and its transportation to the manufacturing plant to whatever the present owners of the coal stockpiles believe the coal should sell for.

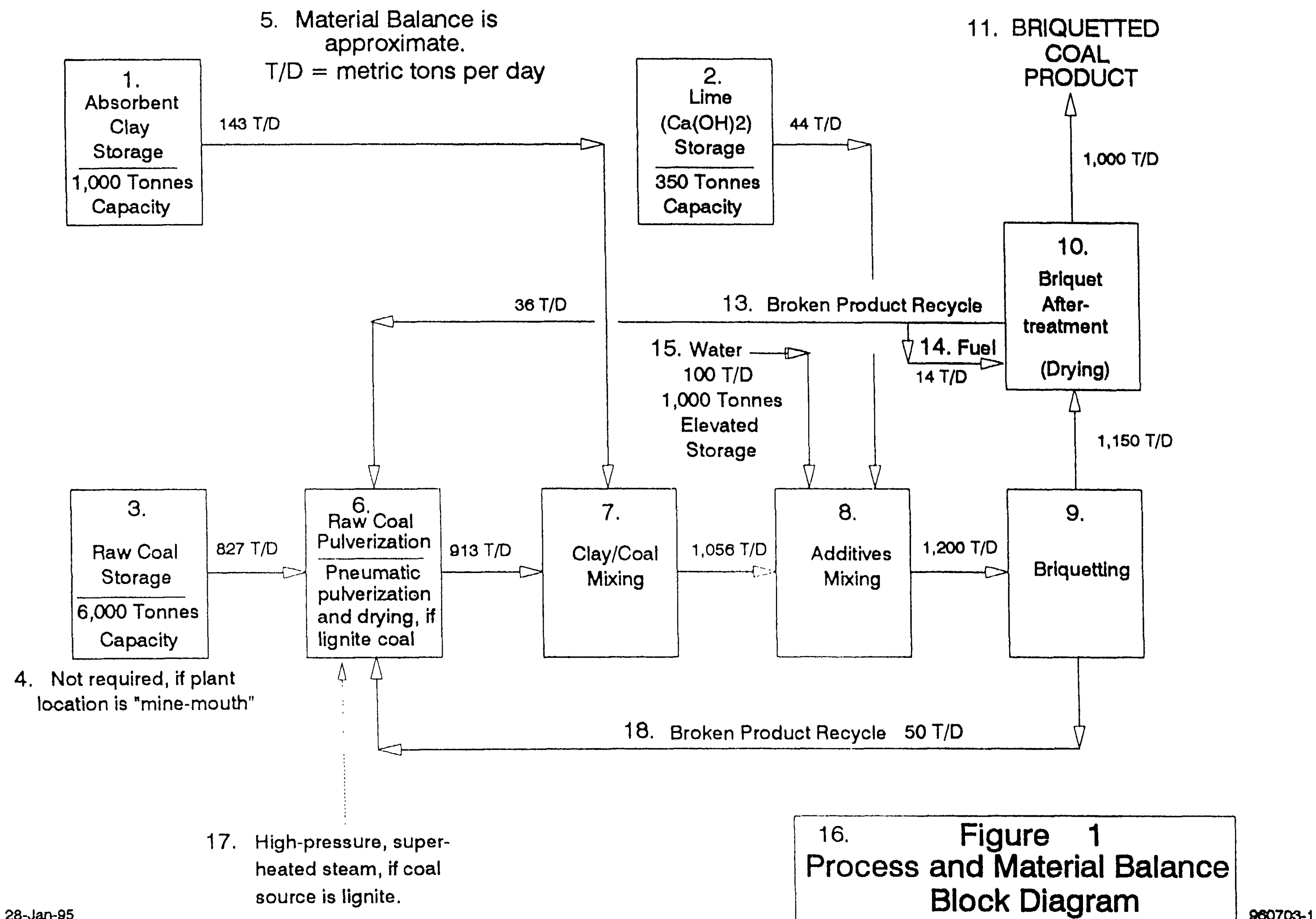
PRODUCTION SCALE

The illustrative briquetting enterprise is based on an arbitrary production scale of 1,000 metric tons per day of finished briquets. This scale is selected only for the purpose of convenience. The actual scale should be selected from market and coal supply conditions.

A block flow diagram showing the main functions for the equipment and an approximate material balance is in Figure 1. The processing shown in this figure should be self-explanatory.

One aspect of the process, which may require specific experimental investigation, is the inherent moisture content of sub-bituminous or lignitic (brown) coals, if this moisture content is substantial. Drying the coal irreversibly to remove its inherent moisture content to acceptable levels could pose a technical problem. The need for drying may depend on meeting a heating value specification for the briquet, on reducing shipping weight, or on both. A consequence of drying is the prospect that the pyrophoric properties of sub-bituminous or brown coals may be enhanced, which can lead to hazardous spontaneous combustion of the briquets during the marketing process.

The statements in Figure 1 concerned with lignite drying may be applicable to Kyrgyz brown coals, and the problem should be addressed with due caution. A demonstration that a brown coal briquet can be marketed successfully, without drying to remove inherent moisture, would be the simplest solution from a processing and production cost standpoint.



16. **Figure 1**
Process and Material Balance Block Diagram

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Table b-8 contains a list, with descriptions, of suggested equipment, corresponding to the functions shown in Figure 1.

CAPITAL AND OPERATING COSTS

Table b-9 contains an estimate of the capital requirements for the construction and commissioning of a commercial facility of the 1,000 tonnes/day capacity shown in Figure 1. The cost data are 1991 U.S. cost data, if such a plant were built in a location on the Gulf of Mexico coast of the United States. It follows, then, if interest develops to pursue this technology track further, that the estimate will have to be converted to reflect the current conditions in the Kyrgyz Republic.

Figures 2 and 3 are plant staffing diagrams, showing personnel requirements and levels of skills. The staffing is shown both for the construction period (in Figure 2) and for the operating period (in Figure 3).

Table b-10 contains an estimate of the payroll including social benefits for the plant staffing, and the build up of the payroll during the first three years of the construction and commissioning project. The cost figures should eventually be adjusted to reflect the current conditions in Kyrgyz Republic.

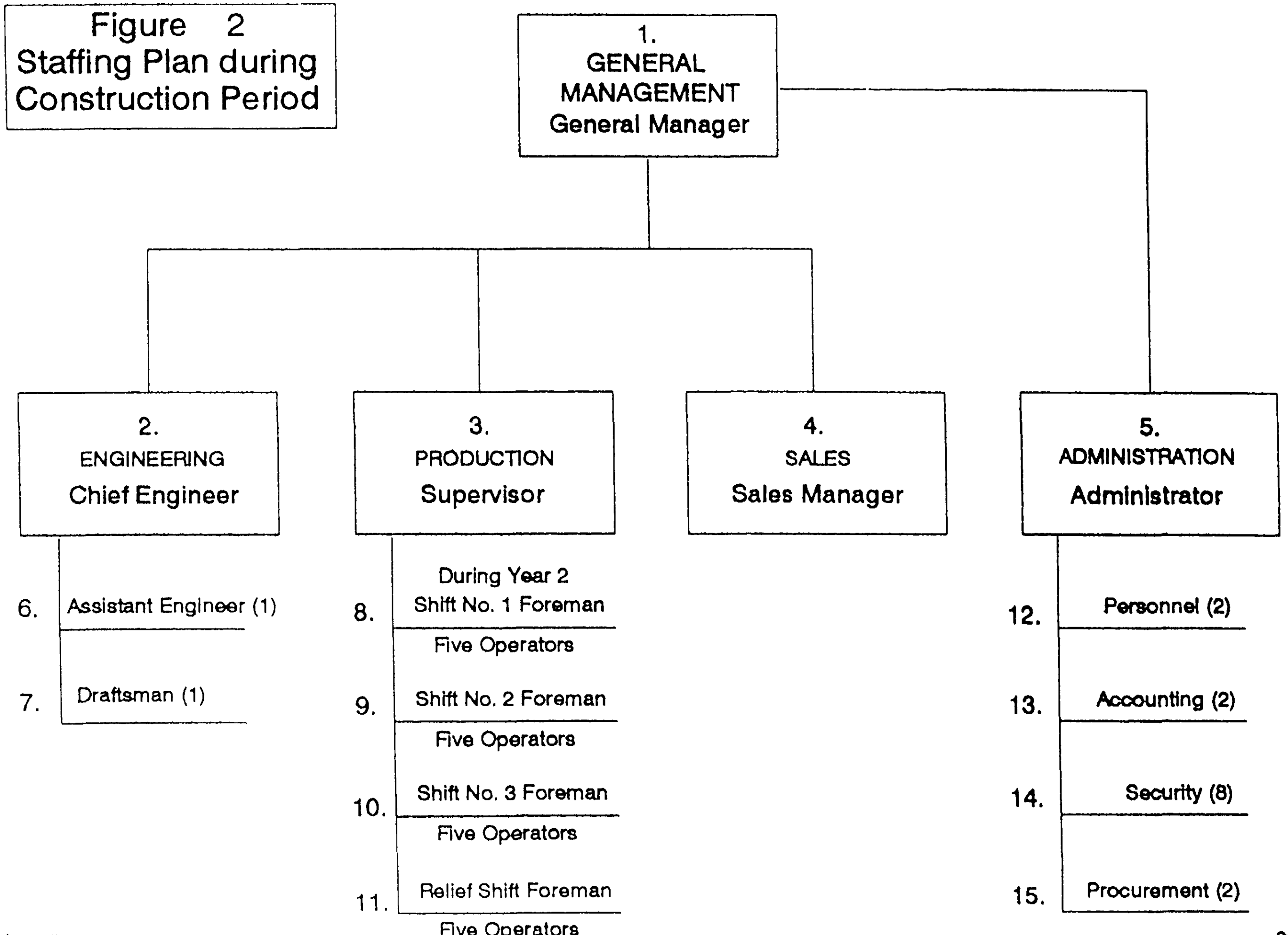
As already indicated above, the data shown in the figures and tables should be used with caution. The data are intended as a guide to planning for briquet development in the Kyrgyz Republic, rather than as inputs for industry development. It cannot be over-emphasized that local conditions in the country regarding costs and personnel should be recognized and the data in the figures and tables revised accordingly.

CONSTRUCTION SCHEDULE

Figure 4 is a schedule which should be possible to follow for the implementation of the construction and commissioning program, based on knowledge of the recipe for the mix to be fed to the presses, finance being available, and the construction of the plant adjacent to the stockpiles of finely-divided coal at the mine. The period of 21 months should be adjusted, depending on the supply of equipment and materials, and on the construction practices in the Kyrgyz Republic.

16.

Figure 2
Staffing Plan during
Construction Period



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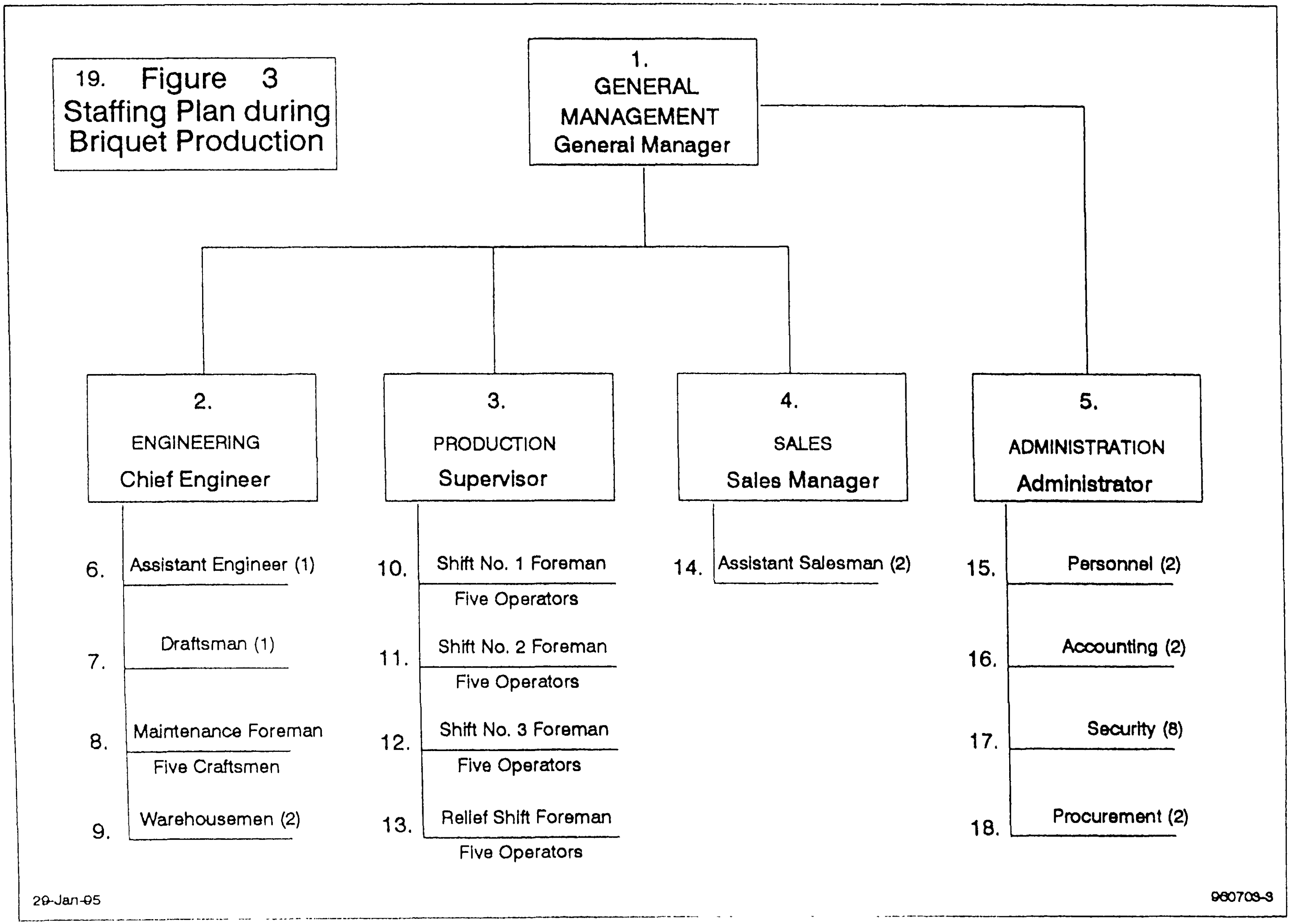
19. Figure 3
Staffing Plan during
Briquet Production
1. GENERAL MANAGEMENT
General Manager
2. ENGINEERING
Chief Engineer
3. PRODUCTION
Supervisor
4. SALES
Sales Manager
5. ADMINISTRATION
Administrator
6. Assistant Engineer (1)
7. Draftsman (1)
8. Maintenance Foreman
Five Craftsmen
9. Warehousemen (2)
10. Shift No. 1 Foreman
Five Operators
11. Shift No. 2 Foreman
Five Operators
12. Shift No. 3 Foreman
Five Operators
13. Relief Shift Foreman
Five Operators
14. Assistant Salesman (2)
15. Personnel (2)
16. Accounting (2)
17. Security (8)
18. Procurement (2)
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22. Figure 4
Briquet Plant Construction and Commissioning Schedule

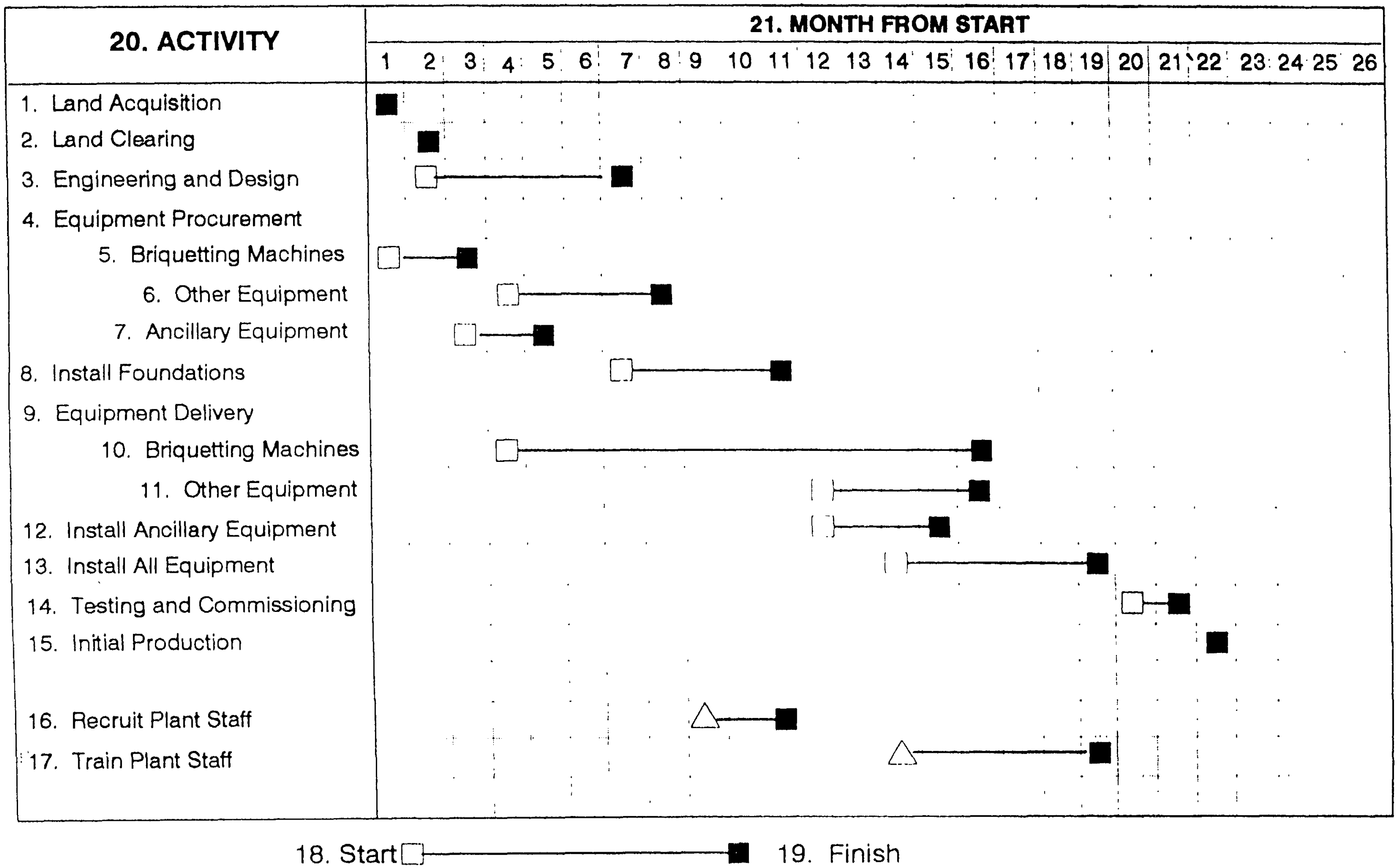

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TABLE b-8
SMOKELESS, WHOLE-COAL BRIQUET MANUFACTURING PROCESS
Major Equipment List and Preliminary Specifications
(See Block Flow Diagram, Figure 1)

1.	Absorbent Clay Storage.	Reinforced Concrete, vertical, cylindrical silo with capacity of 1,000 metric tons, with volume corresponding to the density of fine-particle bentonite clay.
2.	Raw Coal Storage.	(Note: If the plant is located adjacent to the mine producing the fine coal and depending on winter conditions, this equipment item could be deleted.) Reinforced Concrete, vertical, cylindrical silo with capacity of 6,000 tonnes, with volume corresponding to the bulk density of the fine coal by-product from mining.
3.	Raw-Coal Pulverization.	Conventional power plant pulverizer equipment, capable of pulverizing 813 T/D of raw coal combined with 100 T/D of broken briquetted coal to produce a pulverized coal distribution required by the recipe. If the feedstock is a lignitic coal, then the issue of drying will need to be resolved as discussed in the text of this annex.
4.	Clay-Coal Mixing.	Commercial equipment for dry mixing 913 T/D of pulverized coal with 143 T/D of bentonite clay, with a goal of approaching a uniform coating of the clay on the coal particles.
5.	Additives Mixing.	Commercial equipment for uniformly and thoroughly distributing 100 T/D of fresh water and 44 T/D of slaked lime ($Ca(OH)_2$) into 1,056 T/D of the clay coal mix. If an oxidizer (e.g., potassium nitrate) is needed, this can be dissolved in the water beforehand.
6.	Briquetting.	Conventional Belgian-wheel briquetting press(es), capable of continuous operation to produce 1,150 T/D of pillow shaped briquets suited to the market needs.
7.	Briquet Aftertreatment.	Probably a shaft drying tower to reduce the moisture content of 1,000 T/D of briquets to improve ignitability by moisture removal and concomitant development of porosity.
8.	Lime Storage.	Reinforced concrete, vertical, cylindrical silo with capacity of 350 metric tons, with volume corresponding to density of fine-particle slaked lime.
9.	Elevated Water Tank.	Elevated steel tank with a capacity to hold 1,000 tonnes of fresh water at height for gravity feeding water to the process.
10.	Miscellaneous.	Conveyors, elevators, piping, measuring devices and other auxiliary equipment to complete the installations for commissioning.

TABLE b-9
CAPITAL COST ESTIMATE
(U.S.$, Installed at a U.S. Gulf Coast Mine-Mouth Location)
Source: U.S. Engineering Firm - 1991

ITEM	LIGNITE	BITUMINOUS	REMARKS
Process Equipment Cost			
Briquetting Machines	1,500,000	1,500,000	Source: Manufacturer
Coal Pulverizer	44,000	44,000	Conventional Power Plant Type
Clay/Coal Mixer	112,000	112,000	
Additives Mixer	224,000	224,000	
Briquet Aftertreater	300,000	300,000	Shaft Dryer
Lignite Pulverizer	1,656,800	0	
Associated Equipment	200,000	200,000	
Subtotal	4,036,800	2,380,000	Process equipment cost, delivered
Process Equipment Erection	10,092,000	5,950,000	2.5 Multiplier to erect and complete
Auxiliary Equipment Cost			
Clay Storage	320,000	320,000	Reinforced Concrete Silo
Raw Coal Storage	0	0	
Lime Storage	160,000	160,000	Reinforced Concrete Silo
Water Tower	189,000	189,000	Elevated Steel Tank
Subtotal	669,000	669,000	Auxiliary Equipment Completed
Auxiliary Erection	602,100	602,100	0.9 multiplier to complete
TOTAL PROCESSING	15,399,900	9,601,100	
Additional Costs			
Plant Commissioning	100,000	100,000	Allocated Amount
Land Acquisition	200,000	200,000	Ten Acres at $20,000/acre
Land Clearance	50,000	50,000	Allocated Amount
Subtotal	350,000	350,000	
TOTAL PROCESS PLANT	15,749,900	9,951,100	
Contingency, 10%	1,574,990	995,110	
TOTAL INVESTMENT (Rounded)	16,975,000	10,946,000	

TABLE b-10
PLANT STAFFING AND SALARIES (Including Salary Burden)
See Figures 2 and 3, and 4

ITEM	Numbe r	Salary	Lignite	Bituminous	Remarks
YEAR 1					
General Manager	1	30,000	30,000	30,000	
Chief Engineer	1	25,000	25,000	25,000	
Supervisor	1	25,000	25,000	25,000	
Sales Manager	1	25,000	25,000	25,000	
Administrator	1	25,000	25,000	25,000	
Assistant Engineer	1	20,000	25,000	25,000	
Draftsman	1	15,000	15,000	15,000	
Shift Foreman	0	20,000	0	0	
Shift Operators	0	11,250	0	0	
Personnel	2	15,000	30,000	30,000	
Accounting	2	15,000	30,000	30,000	
Security	8	10,000	80,000	80,000	
Procurement	2	15,000	30,000	30,000	
TOTAL	21		$335,000	$335,000	
YEAR 2					
General Manager	1	30,000	30,000	30,000	
Chief Engineer	1	25,000	25,000	25,000	
Supervisor	1	25,000	25,000	25,000	
Sales Manager	1	25,000	25,000	25,000	
Administrator	1	25,000	25,000	25,000	
Assistant Engineer	1	20,000	20,000	20,000	
Draftsman	1	15,000	15,000	15,000	
Shift Foreman	4	15,000	60,000	60,000	
Shift Operators for					
Lignite	24	11,250	270,000		Nine-month year
Bituminous	20	11,250		225,000	Nine month year
Personnel	2	15,000	30,000	30,000	
Accounting	2	15,000	30,000	30,000	
Security	8	10,000	80,000	80,000	
Procurement	2	15,000	30,000	30,000	
TOTAL Lignite	49		$665,000		
Bituminous	45			$620,000	

continued on the following page for Year 3

TABLE b-10 (Concluded)
PLANT STAFFING AND SALARIES (Including Salary Burden)
See Figures 2 and 3, and 4

ITEM	Number	Salary	Lignite	Bituminous	Remarks
YEAR 3					
General Manager	1	30,000	30,000	30,000	
Chief Engineer	1	25,000	25,000	25,000	
Supervisor	1	25,000	25,000	25,000	
Sales Manager	1	25,000	25,000	25,000	
Assistant Salesman	2	20,000	40,000	40,000	
Administrator	1	25,000	25,000	25,000	
Assistant Engineer	1	20,000	20,000	20,000	
Draftsman	1	15,000	15,000	15,000	
Maintenance Foreman	1	20,000	20,000	20,000	
Craftsman	5	15,000	75,000	75,000	
Warehouseman	2	10,000	20,000	20,000	
Shift Foreman	4	15,000	60,000	60,000	
Shift Operators for					
Lignite	24	11,250	270,000		Nine-month year
Bituminous	20	11,250		225,000	Nine-month year
Personnel	2	15,000	30,000	30,000	
Accounting	2	15,000	30,000	30,000	
Security	8	10,000	80,000	80,000	
Procurement	2	15,000	30,000	30,000	
TOTAL Lignite	59		$820,000		
Bituminous	55			$775,000	

ENTERPRISE ORGANIZATION

Ideally, the expectation should be that the management philosophy of a coal mining enterprise in the Kyrgyz Republic should be one of perceiving that the products of the mining operations are two: the marketable lump coal; and marketable smokeless fuel briquets. The transfer price for the fine coal to the briquetting operations then will become an internal matter, the management being concerned primarily with the revenue stream from the sale of the lump coal and the briquets.

Given such an integration of operations, staffing a briquetting operation should be reconsidered, since it should become practical to eliminate many positions. For example, maintenance could be combined as a single service for both the mining operations and the manufacturing operations. The same could apply to such overhead items as personnel, accounting, security, and procurement. A result would be a considerable reduction in the operating costs.

PROBLEMS OF FIGURING ACTUAL COSTS

Finally, no discussion can be useful at the present time with respect to calculating the total cost of production of briquets.
As already noted, the schedule in Figure 4 would begin when the development of the recipe for the mix to be fed to the briquetting presses has been identified and found suited to the market and also acceptable environmentally.

The staffing and staffing costs shown in Figures 2 and 3, and in Table b-10, could be subject to significant reduction through major modifications and revisions.

One example of a possibility in respect to cost reduction lies in the value of the coal fines that currently are unmarketable. On this basis, the fine coal has a zero or negative cost. It should be expected that as soon as interest is shown in acquiring these fines, they will be perceived by present stockpile owners as a "valuable, high-cost" material.

Knowledge of the recipe is required. Costs for the ingredients need to be established. Principles for capital recovery need to be adopted. Operating cost estimates and consequent financial analysis will have to come in due course.

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APPENDIX III. DESCRIPTIONS OF SITE VISITS

a. Alay Coal Region

1. - Kyzyl-Bulak Area

This area is the site of a new open-cut mine operated by a small enterprise. The mine is located about 40 km west of Sary Tash. The coal is contained in a Lower Jurassic unit referred to by mine personnel as the coal-bearing formation. The presence of coal was unreported till very recently when coal fragments were observed in diggings by marmots. The rocks strike north and dip steeply to the east. Only one bed, reported to be 16 m thick, is present.

Mining is by truck and excavator. Overburden is removed by bulldozer and excavator and the coal is transported by private truck to local and distant communities for domestic heating. FOB prices are reported to be about $8.40 per tonne to local users, and at least $9.35 per tonne for more distant users. Because production has been intermittent since the mine opened in 1994, tonneage figures are sketchy, but during October of this year an average of 100 tonnes per day has been produced. This property is currently being explored, and at the time of our visit one core hole had been completed to a depth of 194 m, and a second core hole was being drilled. Future exploration plans call for at least five additional exploration drill holes in the immediate area of the open-cast mine.

b. South Fergana Coal Region

1. Kyzyl-Kiya Area

The mine at Kyzyl-Kiya operates the Lenin-Komsomol shafts and workings 6 km southeast of the town of Kyzyl-Kiya and produces sub-bituminous coal. The market for local uses demands lump coal so there is a screening plant. Until the recent economic/political disruption, fine coal was shipped by rail to thermal plants in Uzbekistan and Kazakstan. Mining started at the end of the last century, and the present mine produced about 450 K.T./year in the mid '70s and again toward the end of the '80s. The present two shafts (700 m deep), plus a slope and ventilation portals date from about 1964. Several other mines are, or have been, operated from this mine headquarters and supply point, with coal hauled here for shipping, so production, size, reserves, etc. may be confused in some reports.

The mine is essentially shut down now because a spontaneous fire in a longwall gob area was incompletely controlled by grout sealing. Further steps to control the fire are in progress, but bad air and high temperature (reported as 35-40 C) limit the operation, and commercial production is just incidental to the cleanup. Our statements about the "present" mine may not, therefore, imply any future. The coal seam is about 8 m thick, with two 3.5 m benches separated by a clay parting. The strata dip 60 deg. in the upper levels and flatten to 18 deg. at 700 m depth. Longwall mining has been done in two benches, with a year interval between, and where possible entries have been driven in rock to provide longer life. In spite of the 12 M.T. balance reserves, the viability of the mine is in doubt because of the fire and the great depth of the operation.

Coal character has been reported as 24% moisture, 20% ash, 0.7% sulfur, 37% VM and 6700 Kc/Kg heating value (daf). The number of analyses and type of samples in these averages is not reported.

2. Almalyk Area

The Almalyk opencast mine produces sub-bituminous coal from pits about 25 km southwest of Osh; it opened in 1961. Production is from a single seam, "Kyzylkiyskiy", about 29 meters thick, though it contains clay partings in the upper portion which total 4 to 9 meters in thickness. The dip of the seam is reported as 12 to 55 deg. south in the present pit which is on the south flank of an anticline that was probably mined earlier at its crest. Farther south the seam forms a syncline or is cut off by a thrust fault below Paleozoic rocks. Overburden rock is presently hauled by trucks about 2.5 km, after excavation at an average ratio of 16 cubic meters per ton of coal. Landslides are very extensive in the pit, and are said to be a cause of significant drop in production even before the present difficult situation with shortages of spare parts and uncertain payments for the product. The coal is screened near the mine and, at least until recently, was shipped by rail from a station 37 km from the mine.

About 40% of the produced coal is fines (< 13mm), which formerly was sold to plants in Uzbekistan and Kazakstan. Presently the price for graded (13-50 mm) coal is said to be 185 som/ton fob mine, and for >50 mm lump is 225 som/ton. Four years ago production was 400,000 tonnes/year, from more than 500 workers. In 1994 production is expected to be only 80,000 tonnes, with about 400 workers.

Blasted overburden is loaded by 5, 8, and 10 cubic meter electric shovels into two 40-ton trucks. Water is not a problem in this pit. Local managers said that only one more cut is planned, and surface operations will cease, though a report dated as recently as 1993 listed commercial reserves of 19 M.T and expected pit life of 60 years.

The operation has proved 1 million cubic meters of cement grade limestone available for development.

An experimental sublevel caving mine is planned at the 1200 m level with the 15 m deep concrete portal to be installed in the coal face below apparently-stable highwall. Experienced underground miners from Kyzyl-Kiya are due to start this work in November, 1994; eventually, it is expected that many local miners can be trained for underground work. Anticipated production is 110,000 tonnes/year, with a minimum 5 year life.

3. Valakish Area

The Valakish mine (probably at a deposit sometimes named Uch-Korgon) is 27 km by road south of Kyzyl-Kiya. The coal seam is essentially vertical, about 15 meters thick in much of the mine, and thins to 4 meters in the upper portion of the mine. Reserves of 3 million tonnes have been blocked out, though exploration is incomplete, and the initial production target is 110,000 tonnes/year. The mining system is an adaption of sub-level caving. Entries are driven in country rock, including a 400 m slope with belt haulage to the surface. A horizontal entry is driven off the slope bottom with cross cuts driven off at angles to the entry into the thick coal seam, using yieldable arches and lagging. Overhead drilling locations are supported with hydraulic posts and heavy timber lagging. These holes are drilled fan-wise overhead twenty meters into the coal, and then loaded and lightly blasted to induce caving. The caved coal is loaded out, working under the heavy timber lagging, onto a chain conveyor and thence out to the slope belt.

Level entries are planned at 20 meters intervals. The system is working according to plan, although we had the impression that one diagonal that "should" have been in rock was actually cut in coal and corners were difficult to maintain.

Unfortunately about 50% fines (< 13mm) are produced, and after screening these are presently stockpiled for lack of market. (We estimate about 2,000 tonnes in the pile.) All coarser coal is sold for household heating and hauled away by single or dual-axle trucks. Except for one kilometer of steep road to the mine, the road through the populated areas is level and asphalted. A 30 ton scale was nearly complete at the mine at the time of our visit. The outside beltways, screens and bins are in the shade much of the winter so sometimes the mine is down because of freezing. And currently diesel fuel for the trucks (probably mostly private) is in short supply. This innovative mine (similar in some ways to the operation in Dzhergalan, though much smaller) is said to produce coal at 80 to 90 som/ton, and the near future looks bright. The exact relationship to the Kyzyl-Kiya coal operations is not clear. Valakish seems to be simply an offshoot, but some people spoke of a "more independent operation than in the past". A small open pit on a nearby saddle was operated by miners from Abshir at one time, but we could not determine the potential for renewed operation there.

4. Abshir Area

The Abshir surface coal mine is about 22 km by road east of Kyzyl-Kiya (about 5 km into the hills from the main Osh / Kyzyl-Kiya highway). The coal seam is an overturned fold, steeply dipping to vertical. Presently mined coal is 8-10 meters thick, although a range of 3-30 meters has been reported. The coal is highly broken, producing almost no lump coal (> 13 mm). It is sub-bituminous, with 20-23% moisture (recorded to 30%), about 25% ash, 0.9-1.5% sulfur.

Some clinker from burning exists in outcrop areas, and a small burn was observed in the pit wall. Reserves are limited to 100-300 K.T., and the economics dictate that the pit will be closed soon because the stripping ratio is now about 20 cubic meters / ton. Water is a major problem in the old pit.

A reserve of 1.2 million tonnes of minable coal in a seam about 5 m thick exist beyond the present pit at one end and development is underway with 10 cubic meters / ton ratio. Much of the present production from the developing pit is weathered coal, and it is sold as a humic soil conditioner and as additive to drilling mud. The market for both is in Uzbekistan - with significant potential if monetary exchange could be arranged.

Abshir was started in the 1930s and modernized in 1967 to reach a maximum production of 500,000 tonnes/year. In 1989 there were 480 employees, but now there are 220. Additional layoffs are planned unless there is a turnaround in production and sales. Coal is trucked the 22 km to the Kyzyl-Kiya cleaning plant. A large deposit of plaster grade gypsum is exposed at the mine and exists for several kilometers at 4:1 stripping ratio. A test shipment of 100 tonnes was made to Uzbekistan, but concrete results are not yet available, and no deal can be made until general agreements for monetary exchange between Uzbekistan and Kyrgyzstan are reached. A mining cost of 60-70 som/ton is estimated. There is a small test facility for gypsum processing at the mine.

c. East Fergana Coal Region

1. Kumbel Area

Kumbel is a complex of open-cut mines located about 65 km northeast of Uzghen. The area is reached by a difficult road that shows evidence of relatively recent damage by stream erosion and mudslides. We were told that the road was closed on March 8, 1994, when a mudslide covered a village along the road and killed about 50 people, some of whom are still entombed. The road was reopened in September. Coal in the Kumbel area is contained in the Lower Jurassic Tuyuk Formation. Mine personnel report a maximum of 53 coal beds, in ascending numerical order, in the sequence, although only 10 are considered to be of economic interest. Beds 9 and 22 are reported to be the thickest. The mine is actually a group of five individual properties: Tashim, Jabad, Malik, Alty Bai, and Nichke. All of these are part of the Small Enterprises Mining Program. Tashin has been operating for three years, and Jabad, Alty Bai, and Nichke started limited operation this year. Malik has yet to be developed.

We visited the Tashim site, where bed 22 is mined. The bed averages about 5.54 m thick and dips about 20 degrees to the east. The overburden is removed by shovel and bulldozer. The coal is mined by a large excavator and trucks, The trucks commonly must be assisted by bulldozer for short distances in and out of the pit. The coal is black coal (bituminous), and is shipped by private truck, presumably as far as Uzghen, for domestic heating. FOB prices are reported to be $9 per tonne with credit, and $7.50 per tonne for cash. Our observations of the site were rendered surrealistic by dense fog (cloud) and we could not observe the relationship of Tashim to the other four actual and prospective mining sites.

Mine personnel report annual production for 1993 of 8,400 tonnes, a significant decline from 1992. No reason was given. Production so far in 1994, basically the month of October, was reported as 2,000 tonnes.

2. Kara-Tyube Area

Kara-Tyube is an undeveloped coal site located about 72 km east- northeast of Uzghen. The last several kilometers of an old road are closed because of rockslides. The coal is contained in the Lower Jurassic Tuyuk Formation and crops out on the steep sides of a valley reminiscent, except for slightly less vegetation, of parts of Appalachia in the eastern United States. The beds dip at an angle of about 20 degrees. Available reports list at least nine beds. In ascending numerical order: 2, 3, 3c, 4, 4-1, 4a, 5, 5a, and 6. Beds 3 and 4 are the most significant with thicknesses of as much as 3.71 and 3.60, respectively. The coal was discovered in 1938, and during the period from 1942 to 1945 at least 16 short tunnels were driven into various beds as a form of exploration. Interest in the area resumed in 1994, but no holes have been drilled. The coal is reported to be black coal (bituminous) of coking quality. Because of a lack of demand for coking coal, this property is of low priority. However, anthracitic coal that may be desirable for domestic use is reportedly present nearby and presumably is of similar thickness and structural situation. The area containing anthracitic coal has reportedly not been explored as much as the coking coal area.

3. Kok-Yangak Area

The Kok-Yangak area is about 63 km northeast of Osh and 18 km north of the Oblast' center of Dzhalabad. The town Kok-Yangak is shown to have 10-50,000 population in the Kyrgyz atlas, and it is served by a good asphalt road (20 km from Dzhalabad) and by a rail line from Dzhalabad and farther east in the Fergana Valley. The mine was operated on the surface, perhaps as early as 1932, and since 1937 through several entries underground. The present extent is about 9.5 square km, with the 72-South and 72-North entries at the +1600 m level and the Kapital-North and Kapital-South entries at +1370m. These latter include the main haulway now. There is an entry at +1200 used as an airway and manway and for rock removal, and another entry is under construction at +1000 m with an incline up to +1200 m. This will provide gravity-flow water for development below +1200 m. Two mechanized longwall complexes have been operated, and odd-shaped sectors are worked in room and pillar system with a "roadheader-type" continuous miner. This is the only continuous miner observed during our site visits.

The mine works three seams, "5", "6", and "M" (Moshchnyy), but the latter appears to have been worked only slightly. In parts of the workings "5" and "6" are close to each other or combined so they are worked as one seam. The general structure is monoclinal in the mine, with 17-21 degree dip to the west. The coal is "D" (long-flame) rank, with 8-12% moisture, and about 7750 kc/kg (daf) calorific value. Ash is listed at 9-16%, and sulfur as 0.7 -0.9%. Written reports show 31-33% VM, but at the mine we were told of 45% unusual VM and "extra quality" utility. Recoverable reserves are stated to be 9 million tonnes out of 32 M.T. balance reserves. The expected life is stated as 13 years. A possible eastward extension to the Markay sector would add 9 M.T. balance reserves. The complicated transport net within the mine (which requires much maintenance), the long haul distances, and the rather complex geological structure at a small scale limit productive capacity to 500 K.T./year. The production in 1994 is expected to reach only 70 K.T., however, because of lack of repair parts, structural materials, etc. In a sense, they have lost market also, but that is not clearly a loss of demand, but rather a loss of cash flow within the whole economy. A few years ago 1000 workers were underground, but the present force is 450, with further reductions anticipated. Cash pay apparently stopped last spring. Coal distribution has been by rail directly from the mine, but the present low production appears to be removed by small trucks only.

d. North Fergana Coal Region

1. Tash Kumyr Area

The Tash Kumyr coal enterprise is located about 140 km northwest of Osh just north of the city of Tash Kumyr in and near the valley of the Naryn River. Four individual mining operations are currently active at the enterprise, another is under development, and at least two other mining operations were previously conducted. The coal is contained in a Lower Jurassic unit referred to by mine personnel as "the coal-bearing formation". This unit is present in a series of west-trending folds that plunge gently toward the west. At least five significant coal beds are reported. In ascending numerical order these are: 0, 3, upper 3, 3g, and 4; evidently other less important beds are also present. The main operation is an underground mine, the Severnay (northern) mine, located at the south end of the property near the mine headquarters. Bed 3, averaging 3 m thick, is currently being mined from a 120m working face by longwall methods. The longwall panel is about 500m long and will be mined out by the end of this year. The coal is removed from the mine by conveyer belt to a cleaning facility where the ash content is reduced from an average of 38% to 32% prior to loading on rail cars for transport to somewhere. Another longwall panel is being mined at another place in the mine from the 0 bed. That panel has water problems and the present panel may be the last coal available in that part of the mine. Bed 3 has recoverable reserves available in two or three more panels. Apparently the mine will be finished at that time, a few years hence.

Just north of Severnay lies the Kara Soo open cut mine. Here the 3 and 3g beds are being mined by truck and shovel with overburden being removed by dragline. Several kilometers north of Severnay and Kara Soo, two additional open cut mines are operating, Kara Tut Central and Kara Tut West. At Kara Tut Central a single coal bed is being mined by truck and shovel; at Kara Tut West a single bed is being mined by truck and shovel with overburden removed by dragline. This area is also the location of the new Tegenek underground mine, which is presently under construction. Mine personnel report the product to be black coal, which is equivalent to bituminous coal.

All of the equipment in the Severnay underground mine is well worn and extensively repaired. Two generations of longwall equipment are represented and neither is state-of-the-art. The two draglines used for overburden removal in the open-cast mines have ten cubic meter buckets with seventy meter booms. We did not inspect them but one was working, apparently efficiently.

The coal cleaning operations use a pneumatic system in conjunction with screens and, reportedly, some hand-picking, to reduce the amount of ash in the product and separate the portion more than 13mm in size from the remainder. Reportedly, the ash content is reduced from 38 or more percent to about 32 percent.

The small coal analytical facility near the cleaning plant was a pleasant surprise. Clean, neat, but not overburdened. They know nothing of the sample but routinely determine moisture, ash and heat content when requested. The equipment is reasonably new and seems well-cared for.

Most of the coal being mined (85%) is for domestic heating, with the remainder (15%) used for power generation. The 1994 production from all of the mining operations is expected to be 140,000 tonnes, a sharp drop from annual production in the past. A large variety of reasons seem to be responsible for the decline in production, ranging from worn-out equipment, fuel shortages, loss of markets [especially for the fine portion of the production], to lack of payment for coal previously produced, and others.

e. Kavak Coal Region

1. Kara Kiche Area

Kara Kiche is an open-cut mine located northeast of the town of Min Kush, but can only be reached by traveling 29 km south from the small town of Chaek, which is about 150 km southwest of Balykchy, the city at the west end of Issyk Kul. Here, two coal beds are present in the Lower Jurassic Tura Kavak Formation. This unit strikes west and dips about 45 degrees to the south as the northern limb of a west-trending syncline. The upper bed, called the compound bed, ranges from 1 to 10 m thick and is not mined. The lower bed, called the basic bed, is reported to average about 50 m thick. The coal is reported to be brown coal, equivalent to subbituminous coal. Mining is by excavator (backhoe) and truck, with overburden removed by shovel. The coal is reported to be transported by private trucks to Balykchy, Naryn, and to nearby communities. Personnel at the mine cite FOB prices as $4 per tonne for fines (less than 3-5 mm) and $8 to $9 per tonne for lump. There appears to be little demand for the fines. Production from this mine will probably reach only 50,000 tonnes this year, a significant decline from past years. Although small-scale mining apparently began about 1940 and recent exploration activities have ceased, this mine is still officially considered under development.

Two shovels, about 5 cubic meter capacity, were removing overburden. Two 45 cubic meter trucks for hauling overburden were present and two excavators, perhaps only one operable, were also present. About eight meters of coal were exposed in the operating pit and trucks were being loaded with coarse coal by the excavator. Two small pumps were attempting with indifferent success to keep water out of the area where overburden was being removed.

We never received a definitive answer as to why production had decreased. At a later time we were told by other parties that overburden removal was the problem and that perhaps the large trucks for overburden haulage were not operating as needed. We have had no chance to confirm this report. We asked and were told that the sale prices cited for the coal only covered direct mining costs and did not include capital recovery for maintenance and repair of equipment etc.

2. Agulak Area

The Agulak mine is an opencast operation located about 15 km southwest of Min Kush. The coal is in the Lower Jurassic Tura Kavak Formation, which here strikes west and dips about 30 degrees to the north as the southern limb of a west-trending syncline. Eight coal beds, in ascending numerical order, are present in the unit but only two of these have been mined, and only one of these, number 6, is currently being mined. This bed is reported to range from 10 to 40 m thick, and to consist of brown coal (subbituminous). Mining is by truck and shovel, and the coal is reported to be transported by private trucks to Balykchy, Naryn, and to local communities. Personnel at the mine cite FOB prices as about $11 per tonne for fines and about $12 per tonne for lump. 1994 production will probably not exceed 50,000 tonnes, a considerable drop from years past. Mining at this site began about 1959 and exploration has apparently ceased.

The known south limb of the syncline has an east-west extent of about seven kilometers with the present Agulak mine area occupying about 2.4 km at the eastern end. About 3.6 km underlies villages, farms, etc., and is considered unavailable for mining. An "old" mining area is present at the western end of the known coal area and an unexplored coal area is present north of the old area. There appear to be no plans for exploration because the measured (B1) and indicated (C1) reserves in the Agulak mine area are about 46 million tonnes and the inferred reserves (C2) are about 18 million. The measured and indicated reserves are at depths of less than 240m.

f. Issyk Kul Coal Region

1. Dzhergalan Area

Members of the team visited the black coal (bituminous) coal mine at Dzhergalan in eastern Kyrgyzstan. They were accompanied by Dokturbi Asanbaevech Marshirov of the Department of Fuel Industry, Ministry of Industry and Trade, Kyrgyz Republic. Marshirov is from the region, has worked in this mine and has many relatives in the area.

The mine is producing 100,000 tonnes per year from Jurassic strata overlain by Paleogene and underlain by Carboniferous. The coal is very steeply dipping, sometimes vertical, but generally is overturned and dips 65-75 degrees to the south. The strike is N 65 E. There are either three beds, two beds, or one bed and they speak of them splitting and coming together. In the area sampled, they are mining two beds, the number 5 and number 4. Number 5 is 7.4 meters thick and number 4 is 3 meters thick, with a 15m interval between them. However, at the next level lower in the mine, from which the stoped coal is now hauled, the two beds appear to have merged into one. We were able to obtain reasonably representative samples by hand picking horizontally across the beds. The sample of number 5 is essentially complete and that of number 4 is missing only the stratigraphically uppermost 20-30cm. Note: the miners refer to the geometrically upper surface as the roof of the bed, although it is actually the base of the coal bed as it was deposited. We sampled at the 2240m level, and they now consider the 2200m level as the deepest that they can go without encountering problems supporting the coal. The overburden increases rapidly at the lower levels because the coal dips beneath the mountain to the south. They now do the stoping under unsupported coal.

The coal is mined by drilling and shooting the coal in stopes, with each stope level being approximately 18-20 meters apart (vertically). The coal is gravity or hand loaded onto conveyors imbedded in the floor, dropped into chutes and then into mine cars, and hauled out of the mine on the cars. There is currently only one haulage entry. The coal is prepared by hand picking and is then screened by size. Two women do the picking and maintain the cleaning/sorting equipment on each shift. Coal is mined on four shifts of 6 hours each. The 100,000 tonnes are produced by a total work force of approximately 470 people.

The team members had the opportunity of spending quite a bit of time talking to the Mine "Director", Akachaev. He is worried that the mine may not stay in operation and that the community of 2000 plus could lose their only source of support. He said that, with input of some capital, the mine could produce 300,000 tonnes per year of high quality coal, and that the coal was desired by the users. There is a problem in that those who want the coal do not always have means of paying for it. He is currently in a bartering mode with some, or much, of the output, including, apparently, delivery to the city heating plant in Kara-Kol in exchange for electricity (which is distributed by the heating plant, though not produced there). The miners have not been paid for the past few months (we do not know precisely for how long) although there has been a distribution of flour and sugar.

The price that the coal sells for is apparently about $20 per ton and that includes an 18% markup over production costs. That is not enough to cover the depreciation or to allow for replacement of cable, etc. Because the miners pay is in arrears, it is assumed that the mine does not receive cash payment for all of the coal. The coal observed underground and on stockpiles at the surface appears to be of good quality with relatively little noncombustible material. We anticipate that it will be of much lower ash content than the coal currently being delivered to the heat and power plant at Bishkek.

2. Soguty Area

The coal mine at Soguty (also identified as Kadzhy Sai) was visited briefly following the visit to Dzhergalan. The mine, which was reportedly closed, is apparently still producing small amounts of coal for local consumption. In the past, the coal was shipped by truck to the Kara Kol heating station but this is apparently not so anymore.

APPENDIX IV. HISTORY OF COAL EXPLORATION

Kashirin, F. T., 1988, Ugol'naya geologiya v Kirgizii za 70 let Sovetskoy vlasti. <Coal geology in 'Kirghizia in the 70 years of Soviet power> Izvestiya Akademii nauk Kirgizskoy SSR <Kabarlary Kyrgyz SSR Ilimader Akademiyasynyn. No. 1, p.72-79.

Coal geology in Kyrgyzstan during 70 years of Soviet power

by F. T. Kashirin

{Translated by Neely Bostick, U.S. Geological Survey[1]}

¶1 The coal industry is one of the oldest branches of the industrial economy in Kyrgyzstan. It originated in the south of Kyrgyzstan (in the present Osh oblast') more than 100 years ago. Coal production began in 1866 in Sulyukta, in 1898 in Kyzyl-Kiya, in 1916 in Tash-Kumyr and Kok-Yangak. Mining was conducted by private enterprises using semi-primitive pits on a very small scale. The geologic basis for developing a coal industry was weak. Coal geologic studies were of a reconnaissance nature, and prospecting-exploration work was absent.

¶2 The publications on coal geology in the territory of Kyrgyzstan were by the well-known Russian geologist I. V. Mushketov. It was he who first described exposures of coal seams in the Kyrgyzstan part of the hills surrounding the Fergana Valley: Sary-Biya (Mayl-Say) – northern Fergana); Sulyukta, Kyzyl-Kiya (southern Fergana); Kumbel', Taldy-Su, Aldyyar (eastern Fergana) [1]. At the same time the geologist G. D. Romanovskiy studied exposures of coal beds in the Kokkinesay area in Sulyukta [2]. Later, more detailed studies of the coal geology of Southern Kyrgyzstan were carried out by M. M. Bronnikov and A. P. Mikhailov in 1889-1913 under the auspices of the Geologic Committee. The famous geologist V. N. Veber also devoted some attention to coal geology during his survey on a ten-verst scale [4]. M. M. Bronnikov and V. N. Veber determined the reserves of several South-Fergana deposits to total 157 million tonnes, including 19.5 m.t. in Kyzyl-Kiya, 19.0 m.t. in Shurab and 52.0 m.t. in Sulyukta.

¶3 The first information about the presence of coal strata in Northern Kyrgyzstan (within the geographical boundaries of Soguty, Ak-Say, Dzhaman-Davan, Turugart, Kok-Maynak) was published by K. I. Argentov in 1911 [5] and V. N. Ryabinin in 1915 [6]. The most complete general work which summarized the results of pre-revolutionary studies on coal geology in Central Asia was by D. A. Nalivkin [7]. Already at that time it had been

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[1] Some abbreviations or acronyms are explained in { }. Place names are given in noun form as translitterated from Russian spelling. Many are hypenated like Wheat-Ridge, but occur elsewhere as WheatRidge or Wheatridge or Wheat Ridge; I have used the variant used by the author.

established that all the coal deposits discovered in Central Asia originated during the Jurassic time of coal accumulation. D. A. Nalivkin wrote that they are: "*deposits of broad plains and wide valleys surrounded and cut off by strongly dissected mountain ranges. Numerous moderate-sized rivers flowing into the plain eroded huge masses of coarse clastic material, which was eroded and swept away for large distances during tumultuous floods. On these coarse sediments formed freshwater basins, only to vanish again under a cover of sands. Most often they had the appearance of extensive swamps which were surrounded and overgrown by a rich, luxurious growth of plants. In lakes and swamps the beds of coal were formed and also lived freshwater fish, pelecypods and insects.*"

¶4 Within the first few five-year plans the Kyrgyz Republic was considered to be the "stoke-box" of Central Asia. The development of a coal industry made necessary the creation of a reliable mineral resource base, for which, in turn, was needed expanded studies of coal geology. Several periods in the development of coal mining and coal geology in Kyrgyzstan during the Soviet era can be recognized, somewhat arbitrarily.

¶5 **1918-1940** During 1918-1927, after nationalization of the coal mines began their reestablishment. By 1928 the coal production had reached a pre-war level (103 thousand tonnes). From this time began preparation of a geologic basis for expanding production of the reestablished operations and for construction of new mines. Large scale geologic mapping encompassed almost all of the main coal-bearing regions in the hills surrounding the Fergana Valley. Prospecting and exploration work included separate parts of the Sulyukta, Kyzyl-Kiya, Naryn (Tash-Kumyr), Kok-Yangak and Shurab coal deposits. This work was done by a large collective of coal geologists, mainly from Leningrad and Tashkent. N. V. Shabarov provided the scientific leadership. The concept of formation of coal strata and coal seams in Central Asia which he proposed was as follows: The Jurassic coal-bearing deposits formed in lagunal-continental conditions. The main coal seams are concentrated in the lower parts of the coal-bearing sequence. Their separation into disconnected coal-bearing areas and their interruption by Cretaceous deposits lying directly on the Paleozoic was caused by the pulse of Alpine mountain building and consequent erosion. On the basis of this concept, N. V. Shabarov postulated the possible discovery of coal-bearing deposits at greater depths under the cover of Cretaceous and younger deposits [8]. This conclusion was an important prospecting idea for discovery of new, concealed, areas of Jurassic deposits bearing industrially valuable coals.

¶6 As a result of the studies mentioned, very significant results were obtained in coal geology. The main one was the creation of a reliable geological basis for development of coal-producing operations on the established deposits Sulyukta, Kyzyl-Kiya, Kok-Yangak, Tash-Kumyr and the discovery by N. V. Shabarov of the Uzgen (East Fergana) coal basin with workable seams having the whole range of bituminous coals from long-flame to anthracite [9].

¶7 **1941-1945.** Before the beginning of World War II the mining industry of Kyrgyzstan consisted of four relatively small coal producing operations which exploited the bituminous coal deposits Tash-Kumyr and Kok-Yangak and the lignite deposits Sulyukta and Kyzyl-Kiya. Production of other mineral resources, including petroleum and ores for non-ferrous metallurgy, were in a rudimentary condition. However, by that time Kyrgyzstan was completely covered by a mid-scale geological survey, which served as the scientific basis for planning and conducting exploration for mineral resources, including coal. In order to study coal deposits in Central Asia, Minugleprom-SSSR {USSR Central Ministry of Coal Industry} organized a special establishment, the Sredazuglerazvedka {Central Asia Coal Exploration} Trust in Tashkent. In Kyrgyzstan, since 1938 worked the Republic Bureau of Geology of Mingeo-SSSR{USSR Ministry of Geology}.

¶8 From the beginning of WW II all efforts of geologists were turned mainly to prospecting and exploration for strategic mineral resources, which included coal. Detailed exploration of new mine fields and coal-bearing sectors was carried out at the working deposits of Kok-Yangak (sectors Kok-Yangak, Sary-Bulak, Tyulek, Markay), Kyzyl-Kiya (field of Mine 6). The main volume of geologic work in coal geology during the war was concentrated in prospecting and exploration for deposits of technological coals (coking coals) in the area of the Uzgen (East-Fergana) Basin. Here the Kyrgyzstan Bureau of Geology explored the Besh-Terek, Zindan and Kara-Tyube + Baybiche deposits and the Sredazuglegeoliya trust explored the Tuyuk and Kargasha deposits. The high pace of development of the coal industry during the war years and the heroic efforts of miners and geologists led to production of 4.0 million tonnes in the first post-war years. Of the large number of distinguished geologists working in the war years, professor N. V. Shabarov, discoverer of the Uzgen coal basin, can be listed first. In these years he studied the basin and consulted for the extensive prospecting and exploration by geologists of the Kyrgyzstan Geology Bureau (L. G. Bel'govskiy, Ye. I. Zubtsov, I. K. Yakovlev, F. T. Kashirin, Z. Ye. Kashirina, I. D. Rogozin, K. D. Musatov, B. I. Rybakov, A. I. Ivanova) and also geologists of the Sredazuglegeologiya trust (Ye. A. Kochnev, Yu. P. Barinkov, A. Gil'metdinova, R. S. Gaft, and others).

¶9 Subsequently, N. V. Shabarov became one of the leading coal geologists of the country, and he worked many years as leader of the coal geology group in VSEGEI (Leningrad). For his discovery of the Uzgen (East Fergana) coal basin he was awarded the title of laureate of the USSR State Prize and Distinguished Scientist of the Kirgiz Republic.

¶10 A large contribution in study of the geology of the Uzgen Basin was made by the Leningrad regional mapping geologist V. N. Ognev. Under his leadership and active work was completed the large scale geologic survey of the most favorable areas of the basin. Together with the famous paleobotanist M. I. Brik he worked out the stratigraphy of the coal-bearing strata of the basin determined the basic features of the paleogeography, which retains its significance to the present day [10].

¶11 **1946 to present.** After the end of WW-II prospecting and exploration for coal was carried out at practically all deposits being mined. However, the main effort was concentrated in the Uzgen coal basin since full industrialization of the basin was included in the fourth five-year economic plan (1946-1959) of the country. Accordingly, a plan of geologic exploration was laid out which included detailed exploration of 12 sectors in the deposits of coking coal Tuyuk and Kargasha for construction of shaft mines with production of 3 million tonnes as well as exploring a route for construction of a rail line to these deposits. The plan for a rail route extending from the Khanabad (Tashkent RR) station to the Sazy region (western part of the Kargasha deposit) was established in 1950. Unfortunately, exploration of the Tuyuk and Kargasha deposits went slowly, mainly because of complications in carrying out core drilling. In 1954 the assignment for detailed exploration of the Uzgen basin was decreased to six underground sectors with an output of 1.8 million tonnes, and the completion date was extended to 1953 {This and the previous date conflict; correct dates are unknown -- Translator} At the same time a new comprehensive project to develop the basin was set, including construction of a rail line to the basin. However, detailed exploration was not completed within schedule, and the final figure for reserves in the Tuyuk and Kargasha deposits was not approved by VKZ {Union Committee on Reserves} until the end of 1955. The development program for the basin was not carried out. In 1956 the institute Sredazgiproshakht {Central Asia Shaft-Mine Design} worked out the basic provisions for development of the Tuyuk and Kargasha deposits. Approximately since this time exploration at these and other Uzgen Basin deposits has ceased and the question of development of the deposits and continuation of the exploration efforts in the remaining deposits of the Uzgen basin remains for all intents and purposes open.

¶12 The most substantial achievement of coal geology during this period was the opening of the Kavak brown coal basin in north Kyrgyzstan. Interestingly, this was done in conjunction with prospecting and exploration for ores of rare metals in the coal-bearing Jurassic strata of the Kavak mountains. The discovery was reported for the first time at the Second Coal Geology Congress in March, 1955, in Leningrad, by F. T. Kashirin, one of the discoverers of the basin [11].

¶13 In subsequent years, from 1953 to 1980 (with interruptions) detailed exploration was conducted at the more favorable deposits of the basin. Up to the present, two coal sectors (Kara-Keche and Agulak + Turakavak) have been prepared, with explored reserves adequate to supply twoopencast mines, with 4-5 million tonnes combined capacity. Construction of an opencast mine has begun at the Kara-Keche deposit, which has now been reached by an electrical transmission line and a gravel road connecting with the Kochkorka to Chayek auto road. In the development plan for coal industry in Kyrgyzstan for 1986-1990 is projected expansion of the output of the Agulak + Turakavak opencast mine to 1 million tonnes.

¶14 At the deposits opened in this period prospecting, exploration, and thematic studies have been carried out. In the 50's and early 60's at the Sulyukta deposit were conducted detailed exploration of the northern sectors (geologist B. Ye. Dimitruk), parcel No.8

(geologists V. A. Kramer and N. V. Il'chenko), No.12 (geologists V. A. Kramer and P. P. Konovalov), the field of mine No.16 (geologists Yu. S. Ler-Khodkevich and V. I. Utkin), parcel No.5 (M. I. Yaskovich and R. S. Mangel'din). This work provided reserves equal to the output of the active underground mines No.6/18 at Sulyukta (Kyzyl-Bulak) and created a number of reserve parcels (field 11 and others).

¶15 At the Kyzyl-Kiya deposit during these years practically the entire territory was explorated for coal sectors and parcels. This effort provided reserves to allow construction of the Dzhindzhigan underground mines and the open pit mines Abshir and Almalyk, and allowed evaluation of the reserve Eastern Sector. This exploration was carried out by many geologists based in Frunze and Tashkent (A.A. Gavrilin, Sh. Tekenof, I. M. Mel'kovitskiy and others).

¶16 Within the actual Tash-Kumyr deposit the inadequate reserves in one sector (Kara-Su open pit; Severnaya underground mine) and drastic worsening of mine/geological conditions in others (Kapital'naya mine) led to basic prospecting and exploration to prepare for exploitation of the coal-bearing sectors and areas beyond Tash-Kumyr. With this aim the Tegenek deposit, 45 km north of Tash-Kumyr, was explored in detail. The proved reserves of this deposit provide initially for construction of an open pit, and after surface reserves are worked out -- shaft mines.

¶17 At the Kok-Yangak deposit, in post-war years production has been mainly from drift horizons. At the present time at these horizons and in part lower (the region of shaft No.40) the reserves are worked out at coal sectors Kurgan-Tash, Kok-Yangak, and Sary-Bulak; the main front for exploitation work has shifted in a southern direction, encompassing the areas Tyulek and Markay (Southern Kok-Yangak). Preliminary exploration of these areas was carried out in 1941-1943, and detailed exploration of Southern Kok-Yangak in 1955. Calculation of reserves of the entire deposit (The Northern Area, shaft No. 40, Kapital'naya stsol'nya, shaft No.45, Kok-Yangak-Glubokiy and Sary-Bulak) was carried out by the Kyrgyzstan Geological Bureau in 1963.

¶18 At deposits of the South Issyk-Kul' coal region in the region of Dzhergalan and Soguty, small-scale exploration has been carried out from time to time to provide reserves for the two active shaft mines here. Their total yearly production does not exceed 200 thousand tonnes. Because of their reserves and size of output, the named deposits and mines have only local significance.

¶19 In this short paper only certain aspects of development of coal geology in Kyrgyzstan during the Soviet era have been presented. I would say that the most striking is the creation of a large (for Central Asia) geologic base for the further development of the coal industry in Kyrgyzstan. While before the revolution (1913) the predicted coal reserves were reckoned at 157 million tonnes, at the present they amount to 33,000 million tonnes. That is, they have grown more than 200 times, including a reserve balance of 2,200 million tonnes.

¶20 In past years at many deposits worked for a long time (Tash-Kumyr, Kok-Yangak, Kyzyl-Kiya) the reserves in certain sectors are worked out, whereas in others the mining/geological conditions have greatly worsened. However, as a whole, the coal industry of Kyrgyzstan has favorable perspectives not only for continued existence but for further large-scale development. The perspectives include the still untouched Uzgen and Kavak basins. The Kavak basin deserves special attention because of its uniquely thick coal seams, which with justice may be called the "cream" of solid fossil fuel. In the Kavak basin even today is possible surface mining of coals on a large scale.

¶21 In case of need, the Uzgen Basin may become the basic provider of high quality bituminous coals for the entire Central Asian region and the base for technological coals -- the raw material for a coke-chemical industry.

¶22 The results of prospecting and exploration for coal, the mining geology, and the scientific studies in coal geology which were carried out over many years by a large number of coal geologists have been published in monographs and numerous articles, but their greatest fruit is found in the book Coal Basins and Deposits of Central Asia [12]. This volume contains quite complete accounts of geology (stratigraphy, tectonics, depositional conditions), coal occurrence and perspectives for industrial development of nearly all coal basins and deposits of Central Asia, including those in Kyrgyzstan. It contains also description of petrography, chemistry and technological properties of the coals; special attention is devoted to evaluation of raw resources for coal-based industry.

¶23 In a short article it is impossible to list all coal geologists of the old and young generations who have invested their work in creation of a raw material base of a coal industry of Kyrgyzstan and who continue their valued work toward further expansion of our knowledge of the coal riches of Kyrgyzstan.

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Basic development stages in the coal-production industry and in coal geology of Kyrgyzstan from 1917 to 1987

1 **Basic stages in development of the coal industry; growth of coal production**	2 **Directions in geological exploration work; important achievements; discoveries**	3 **Achievements in coal geology**
1918-1928 Nationalization of the coal pits. Reestablishment of them after the civil war and liquidation of Basmachism. Coal output reached the pre-war level (103 thousand tonnes).	In 1927 were begun large scale geological mapping and detailed studies of individual regions with coal deposits. in Kyrgyzstan (N. V. Shabarov). The first geological exploration for coal in Kyrgyzstan was conducted at Kok-Yangak in 1926-1928 under the leadership of the Leningrad geologist Ye. O. Pogrebitskiy.	The first general compilation of material on coal geology in Central Asia, including Kyrgyzstan (D. V. Nalivkin, 1926).
1929-1940 First and second five-year plans. Growth of coal output from 103 to 1200 thousand tonnes.	Exploration was expanded to provide coal reserves for working operations and to support construction of new shafts at coal deposits in Kyzyl-Kiya, Sulyukta, Tash-Kumyr, and Kok-Yangak. A new (for Kyrgyzstan) coal basin was discovered -- the East Fergana basin, which includes the whole range of coals from long-flame bituminous to anthracite.	First publications about the geology and coal resources of Uzgen (East Fergana) bituminous coal basin (N. V. Shabarov, 1939).
1941-1945 Period of WW-II. Growth of coal output from all coal-producing operations: In the five-year period about 7 million tonnes was attained, 1.5 million more than in the pre-war five-year period.	Extensive detailed work at all working deposits in order to increase their output (new sections, and shafts at surface mines) suitable for new or reconstructed active producing operations. Detailed exploration of coking coals in the Uzgen basin (Tuyuk and Kargasha deposits) were begun.	

1946-1958----------------

Re-establishment and development of the economy. "The law of five-year planned reconstruction and development of the economy of the USSR". Growth in coal output to 3.8 million tonnes. Development of surface mining. Geological reserves of explored coal in Kyrgyzstan reached 15,060 million tonnes in January, 1955.

Continuation of prospecting and detailed exploration for coal in the whole territory of the Republic. Discovery of the new Kavak coal basin, in which the coal-bearing sequence contains the basic Republic reserves of energy lignite available for surface mining. Detailed exploration of Kara-Kiche deposit, the most favorable for development in the Kavak coal basin.

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1959-1987---------------

Basic output of coal mainly from deposits established earlier. Output maintained at 4 million tonnes. Explored reserves of high-quality bituminous coal at Uzgen and of brown coal at Kavak basin practically not exploited.

In conjunction with development of reserves at many existing underground operations, the basic geological work was directed toward establishing new production units at existing underground and surface mines. Prospecting to evaluate possible rare-metal ore potential in coals and adjacent rocks was undertaken at all main coal operations.

Publication of volume 6 of <<Geologiya mestorozhdeniy uglya i goryuchikh slantsev SSSR>>, titled Coal basins and deposits of Central Asia (collective of authors, 1968). Monographs on separate coal basins and deposits of Kyrgyzstan (F. T. Kashirin, 1964, 1975).

Repeated recalculation of reserves. Depending on assumed conditions and depth for calculation, reserves in Kyrgyzstan evaluated as (thousand million tonnes): 1956 --33.0; 1979 -- 27.4. (In 1913 coal reserves of entire Central Asia amounted to 157 million tonnes.) Net conditional reserves amount to 2,200 million tonnes.

Coal conference in Frunze (1978), organized by the Bureau of Prospecting and Exploration for solid fuels, Mingeo SSSR (V. F. Cherepovskiy). The conference considered and adopted resolutions on problems of expanding solid fuel resources in Central Asia, exploiting the resources and further directions in geology of the solid fuels.

Places (for Kashirin article)
Place Names in article / = Not verified:

Abshir razrez
/**Agulak-Turakavak** ploshchad'
AkSay urochishche.
/**Akok-Maynak** urochishche.
/**Aldyyar** (eastern Fergana)
Almalyk razrez
Arulak-Turakavak razrez
/**Besh-Terek** mestorozhdeniye
/**Dongurme** reka
/**Dzhaman-Davan** urochishche.
Dzhergalan mestorozhdeniye
/**Dzhindzigan** shakhta.
Frunze
Issyk-Kul' rayon
/**Kapital'naya** shtol'nya
/**Kapital'naya** shakhta
KaraKeche ploshchad'
KaraKeche mestorozhdeniye
Kara-Su uchastok
Karatau
/**Kara-Tyube +Baybiche** mestorozhdeniye
/**Kargasha** mestorozhdeniye
Kavak basin
Khanabad RR station
Kochkorka-Chayek
/**Kokkinesayskay** ploshchad' v Sulyukta
/**Kok-Maynak**
Kok-Yangak-Glubokiy
Kok-Yangak mestsorozhdeniye.
Kok-Yangak uchastok of Kok-Yangak mestorozhdeniye.
/**Kumbel'** (eastern Fergana)
/**Kurgan-Tash** uchastok
Kyzyl-Kiya (southern Fergana) mestorozhdeniye.
/**Maarkay** uchastok of Kok-Yangak mestorozhdeniye.
/**Markay** (Yuzhnyy Kok-Yangak) ploshchad'.
/**Mayli-Say**
Naryn mestorozhdeniye. (Tash-Kumyr)
Osh oblast'
Przheval'sk uyezd
/**Sary-Bulak** uchastok of Kok-Yangak mestorozhdeniye.
Sary-Biya (Mayli-Say) (northern Fergana)
Sazy urochishche (western part of Kargash mestorozhdeniye)
Semirech'ye
/**Severnaya** shakhta
/**Shurab** mestorozhdeniye.
/**Suguty** urochishche.
/**Soguty** mestorozhdeniye
Sulyukta (southern Fergana) mestorozhdeniye.
Syrdar'ya
/**Taldy-Su** (eastern Fergana)
Tash-Kumyr mestorozhdeniye.
/**Tegenek** mestorozhdeniye
/**Tura-Kavak** ploshchad'
/**Turugart** urochishche.
/**Tuyuk** mestorozhdeniye
/**Tyulek** uchastok of Kok-Yangak mestorozhdeniye.
/**Tyulek** ploshchad'.
Uzgen basin (East-Fergana Basin)

/**Zindan** mestorozhdeniye