U.S DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

A PRELIMINARY REVIEW OF COAL EXPLORATION ACTIVITIES CONDUCTED BY THE GOVERNMENT OF ARMENIA AND THE COAL RESOURCE POTENTIAL OF ARMENIA

By

P.D. Warwick[1], B.S. Pierce[1], and E.R. Landis[2]

Open File Report 93-681

Prepared in cooperation with the Department of Underground Resources, Republic of Armenia, under the auspices of the U.S. Agency for International Development.

[1]U.S. Geological Survey, Reston, Virginia
[2]U.S. Geological Survey, Denver, Colorado

CONTENTS

ILLUSTRATIONS

A PRELIMINARY REVIEW OF COAL EXPLORATION ACTIVITIES CONDUCTED BY THE GOVERNMENT OF ARMENIA AND THE COAL RESOURCE POTENTIAL OF ARMENIA

By

P.D. Warwick, B.S. Pierce, and E.R. Landis
U.S. Geological Survey

SUMMARY AND SUGGESTIONS

A coal resource assessment team from the U.S. Geological Survey (USGS), in cooperation with the Armenian Department of Underground Resources (DUR) and elements of the Ministry of Energy and Fuel, has completed an initial visit to Armenia under the auspices of the U.S. Agency for International Development (USAID). The visit included discussions of the coal resources, identification of problems associated with on-going exploration and development activities, and field visits to selected solid fuel areas. The USGS team will return in November with a draft of the final report for discussion of conclusions and recommendations with Armenian counterparts, representatives of USAID, and the American Embassy. The final report, which will contain tabulated coal-sample analytical results and detailed recommendations, will be submitted to the USAID by the end of December 1993.

Preliminary conclusions are that: 1) Armenia has usable deposits of coal that could form a viable, though relatively small, component of Armenia's energy budget; 2) on-going exploration and development activities must be augmented and expedited to increase understanding of the coal resource potential and subsequent utilization; 3) deficiencies in supplies (primarily fuel) and equipment (replacement of aging parts and units) have greatly reduced the gathering of necessary resource data; and 4) training of Armenian counterparts in conducting and managing coal exploration activities is desirable.

INTRODUCTION

A memorandum of discussions between the U.S. Agency for International Development (USAID) and the Armenian Ministry of Energy and Fuel was signed in September, 1992, and discussions were initiated to form the current cooperative USGS and Armenian investigations of Armenia's coal resources.

In January 1993, the U.S. Geological Survey responded to a request for a proposal by USAID for an assessment of the coal resources of Armenia. The objectives and scope of study for the USGS team are as follows:

1) Collect all relevant data available in the United States concerning coal in Armenia;
2) Collect and review coal data available in Armenia, and in Russia if necessary;
3) Organize and evaluate the data to produce a data base of relational format;
4) Judge and recommend desirability and form of coal exploration and develop drilling programs to increase knowledge of the coal resource potential of Armenia;
5) Identify needed equipment and training, and develop summaries of the needed equipment and programs for training; and
6) Prepare a formal report to USAID for submittal by the end of Calendar Year 1993 for use in Calendar Year 1994.

The preliminary report presented here summarizes the findings and recommendations of the USGS team to date. A review of activities and a short description of the primary coal-bearing areas in Armenia is included. The tentative conclusions herein do not necessarily represent the final conclusions that will be contained in the formal report after all field and laboratory data have been examined, integrated, and summarized.

Previous work

There have been very few reports published about the coal fields of Armenia. Some subsurface data has been collected, however, and DUR geologists have prepared a few preliminary unpublished geologic maps. The general reviews of the geology of Armenia by Kharajian (1915) and Aslanian (1984) may be of help for those interested in the geologic setting of the country. The Idjevan coal deposit has been generally described by Geoletian (1988), and by Mkrtchyan and Martirosyan (1975).

Review of activities, July - August, 1993

A USGS coal resource assessment team, consisting of Edwin R. Landis, Brenda S. Pierce, and Peter D. Warwick arrived in Armenia on July 23 and initiated discussions with representatives of the Armenian government organizations that have responsibilities in the field of energy resources, and especially for solid fuels. The primary counterpart to the USGS in Armenia is the DUR, which has the responsibility for exploration of the mineral and fuel resources of Armenia, including determination of the feasibility and form of recovery operations. Field parties from DUR are currently investigating solid fuel resources in at least five areas in the country. Exploration activities, including mapping, exploratory trenching, and core-drilling, are currently being conducted by DUR in an attempt to assist in alleviating Armenia's shortage of energy. All coal exploration and exploratory trenching or mining in Armenia is currently done by the DUR. The Armenian Ministry of Energy and Fuel ultimately has the responsibility to develop the resources identified by the

DUR.

Successful cooperative activities to date between the USGS team and DUR include 1) discussions of the amount and type of counterpart activities required, 2) identification of known coal resource data including maps and coal quality and resource data, 3) arrangement for the transfer of such data to the USGS team, and 4) field site visits to those areas selected as of highest priority and/or as representative of other potentially similar deposits.

Acknowledgments

The firm support of Mr. Lazar Y. Sarkissian, Minister, DUR, has contributed greatly to the success of the cooperative efforts to date. Mr. Artur Ohanian, Head of Geology Department, DUR, and Mr. Levon Hakobian, Chief Geologist for Fuel Energy and Raw Material, DUR, have rendered important assistance. Mr. Andranik Agabalian, Chief Specialist, Ministry of Energy and Fuel, provided critical guidance during the beginning stages of the program. The patient assistance of individual project or field site geologists of DUR is also greatly appreciated. Close counterpart relationships are absolutely vital to ensure success of the program. Mr. Avetik Ghoukassian (USAID, Yerevan) provided invaluable assistance in facilitating many aspects of our work.

The results of a preliminary investigation of coal in Armenia by the Bechtel Corporation (funded by USAID in 1993) were helpful to the USGS team.

Funding for this work was provided to USGS through a Participating Agency Service Agreement (PASA) No. CCN-0002-P-ID-3097-00 between the USAID and the Department of Interior/USGS.

FIELD SITE VISITS

Six field sites were visited during July and August 1993: the Idjevan coal area, the Djermanis coal exploration area, the Shamout coal drilling site, the Djadjur coal area, the Makarovite coal and peat briquetting plant, and the Aramus oil shale drilling operation (fig. 1). When possible, the USGS team collected detailed samples. The samples will be submitted to laboratories in the United States in order to determine the quality and heating value of the fuel. The results will serve as a comparison with previously existing data obtained from Soviet and Armenian laboratories.

All field site visits were arranged by the DUR through the cooperation of Mr. Ohanian and Mr. Sarkissian. The visits enabled information from very knowledgeable DUR field geologists to be integrated into the program.

Idjevan

The Idjevan coal area (1 on fig. 1) is the best understood coal region of Armenia because coal exploration efforts of the

former Soviet Union and Armenia were concentrated in this area. There are as many as 20 shallow test bore holes, but no deep or regional exploration holes in the area. The coal, which is Jurassic in age, appears to be bituminous in rank. Bituminous coal, such as that at Idjevan, is the highest ranked coal the team observed in Armenia and therefore should have the highest heating value. The known coal-bearing zone at Idjevan is 25-26 m thick in the thickest places, including noncoal partings. Average coal thickness is approximately 16-18 m. The beds dip at a very steep angle (50°-70°). The coal occurs in a highly sheared, tectonically active area, and as a result the coal crumbles and breaks very easily. This is an advantage in the current use of this coal, which is mixed with peat to form briquettes. The briquettes are made at the Makarovite briquetting plant and then are sold as fuel for cooking and heating stoves. (The briquettes will be discussed in the Makarovite section below.)

The Idjevan coal area contains the largest known coal resources within Armenia. According to unpublished DUR files Idjevan has an estimated 750,000 tons of coal in place. Approximately 2,000 tons of coal have been mined this year at Idjevan and the current DUR mining plan calls for a total of 12,000 tons to be mined this year. It is questionable whether the DUR can fulfill this 12,000 ton mining plan because of fuel shortages and potential equipment limitations. There is apparently a great demand for the Makarovite briquettes.

In terms of long-range, large-scale development, however, there are several disadvantages to the Idjevan coal. The steep dip of the coal bed makes mining extraction of the coal difficult at best. In addition, the coal, although seemingly of very good quality, is mixed with great quantities of rock partings which detract from the value of the coal. These problems are not insurmountable, but must be taken into account for long-term development planning. For example, the steep dip and natural breakage of the coal may in fact lend itself to some particular mining methods. Furthermore, the Idjevan coal would have to be cleaned (washed) in a processing plant before it would be suitable for burning in a power plant or for use as a coking coal. This practice is common in the U.S.A. and elsewhere. The Armenians are reportedly establishing a testing facility for coal washing and preliminary tests are underway at the Armenian State Engineering University (see Appendix I).

Samples collected at Idjevan

The USGS team collected 4 coal and 3 rock samples from selected parts of the Idjevan coal interval. These samples are representative channel samples of intervals that contain entirely coal, and intervals of mixed coal and rock. The samples have been shipped to the U.S.A. for analytical tests.

Previous analyses of Idjevan samples

Many samples from the Idjevan coal zone have been analyzed by Soviet and Armenian laboratories but most of the results have not been published. A complete listing of the previous results of coal tests are not tabulated at this time. A preliminary review of DUR data, however, shows that dry ash yields range from 20 to 75% and heating values range from 7000 to 8000 kcal/kg (dry basis). The coal is reportedly a coking coal. The new samples collected by the USGS team will be valuable because of the difficulties of comparing the old Soviet data and the new Armenian data to the type of analyses routinely performed in the U.S.A.

Djermanis

The Djermanis coal field is located southeast of Yerevan (2 on fig. 1). The coal, which is the oldest known coal in Armenia, occurs in upper Triassic rocks. Three coal beds occur in two fault blocks that are probably less than 5 km wide and separated by a few kilometers. Two coal beds are thin (<0.25 m) and laterally discontinuous; the third bed, known locally as the No. 2 bed, is 0.3 to 0.7 m thick. Although exploration activities to date have been minimal, the DUR currently estimates only 50,000 tons of "proven" coal for the No. 2 coal bed. Preliminary investigations include approximately 25 exploration bore holes that were drilled during the Soviet administration. In the area that the USGS team visited, the No. 2 coal bed dips about 20° north.

As in the other coal areas of Armenia, additional exploration, in particular drilling, would be needed to prove out the extent of the resources at Djermanis. An underground mine has been planned and started for the Djermanis coal. Lack of available timber for roof support has halted development, however, and this problem could hinder long-term development in the area. No coal has been mined this year.

Samples collected at Djermanis

The USGS team collected 4 incremental samples of the Djermanis No. 2 coal bed. These have been shipped to the U.S.A. for analytical tests.

Previous analyses of Djermanis samples

Tabulated analytical data for the Djermanis coal are not available at this time. The DUR geologists consider this coal to be a relatively high quality coal because of its low sulfur content, even though it has a relatively high ash yield (25 to 30%). The heating value is reportedly 6,200-8,400 kcal/kg. It is believed by the Armenian geologists that the superior quality of this coal, particularly the high heating value, warrants increased exploration and development.

Shamout

The Shamout coal area is located in north-central Armenia (3 on fig. 1) and the coal rank reported is bituminous. The coal deposits occur within middle Miocene (or lower Miocene?) rocks which form a contiguous structural block that covers approximately 10 km^2. The bituminous rank, relatively high for Miocene-age coal, is probably caused by the intrusive igneous rocks in the area. The DUR has drilled two holes in the area during the last year and previous Soviet exploration includes several drill holes. The USGS team examined core obtained from a DUR drill hole that was completed the day before their visit. The core contained several coal and carbonaceous shale intervals, each less than 1 m thick, which occur in a 10-m-thick zone starting at a depth of about 140 m below the surface. Core recovery from the coaly zones was poor, and the complete coal-bearing interval was not recovered. The cored coal and carbonaceous shale beds were intercalated with claystone partings. The DUR has dug several exploration trenches in the area where the coaly interval subcrops and the same interbedding of coal, carbonaceous shale and claystone was evident. The beds dip about 20° in the area.

The overall quality of the Shamout coal is significantly reduced by the relative amounts of rock and carbonaceous shale intermixed with the coaly layers. The coaly layers thus far observed are very thin compared to the coal at Djadjur or Idjevan. Several exploratory drill holes need to be drilled in the Shamout area to confirm the coal thickness and to obtain samples for analyses so the true potential of the area can be better assessed. The drilling operations recently completed by the DUR were delayed by frequent shut-downs due to lack of fuel, and core recovery in the coaly zone was not sufficient to evaluate the coal interval adequately.

Tentative plans for utilizing this coal include briquetting, similar to the current practice at Idjevan of mixing coal with peat. Because of the apparent relatively poor quality of this coal, this may be the most viable (or only) use for this coal.

Samples collected at Shamout

The USGS team collected 3 samples of the coal and carbonaceous shale that had been exposed by trenching. The samples will be used chiefly for palynological analyses because the coaly material was too weathered for standard analytical analyses.

Previous analyses of Shamout samples

No previously existing analytical data for the Shamout coal area has as yet been acquired by the USGS team.

Djadjur

The Djadjur coal area is located in northwest Armenia (7 on fig. 1). Djadjur coal is younger (Oligocene/Miocene) than

Idjevan coal, and lower in rank (apparently subbituminous). Coal of this rank, however, may be suitable for electric power generation. In addition, the Djadjur coal does not crumble like the Idjevan coal, but rather breaks into chunks which are more suitable for burning in cooking and heating stoves.

There are six known coal beds within the Djadjur coal area. The coal-bearing strata are subhorizontal and are covered with surface debris that varies from 1 to many 10's of meters thick. Two beds, No. 2 and 6, are 2.5 m and 1.3 m thick respectively. Only the No. 2 coal bed is currently mined. The other beds range from 30 cm to 40 cm thick. Six of the seven coal beds are relatively close together (total coal-bearing interval is 10-15 m). All six beds could possibly be recovered and utilized; thereby increasing production significantly. When the USGS team was at the Djadjur excavation site, there were 8 seven-ton trucks waiting to purchase coal (for 13,000 r, or about $13, per ton). The trucks reportedly deliver the coal to government and private consumers in Gyumri (Kumayri on fig. 1) and return daily. All the mining at Djadjur, including the removal of the overburden, is done by a bulldozer and a backhoe. No reclamation is underway.

The DUR has estimated 500,000 tons of "proven" coal within the Djadjur area. There has been very little exploration beyond preliminary drilling at this site, however, and further exploration, particularly drilling, is necessary to determine the true extent of the coal within this region. The Djadjur coal appears to be of very good quality, low in both ash yield and sulfur. Djadjur coal appeared to be much better than the coal at Idjevan in terms of ash content and apparent ease in minability.

According to DUR, only 3,000 tons of coal are to be mined this year at Djadjur, 1,000 tons of which have already been produced. There is a considerable demand for this coal and relatively minor changes in mining practices, such as better excavation equipment, could increase production substantially. Unlike the Idjevan area, the Djadjur area does not have any trees, and therefore environmental disruption of forested land, which is a concern in Armenia, would be negligible.

Samples collected at Djadjur

The USGS team collected 5 coal bench channel samples and 2 rock samples from the Djadjur No. 2 coal interval. The samples have been shipped to the U.S.A. for analytical tests.

Previous analyses of Djadjur samples

The following DUR data are summaries of analytical results from Djadjur samples analyzed in laboratories of the former Soviet Union and the Armenian State Engineering University (formally the Polytechnic Institute):

Bed	Heat value K cal/kg		Ash %		Moisture %		Sulfur %	
	Max	Min	Max	Min	Max	Min	Max	Min
2	3880	3038	45.13	20.34	24.61	6.94	3.02	2.37
3	4636	4060	12.63	11.97	24.90	17.97	3.56	3.03
4	3697	3007	39.12	29.24	18.24	16.2	3.03	1.25
5	4753	4195	12.12	9.05	25.58	25.4	2.03	----
6	5702	3076	41.56	7.47	24.50	7.18	3.87	1,38

Aramus

The Aramus oil shale area, northeast of Yerevan (13 on fig. 1), contains large quantities of oil shale (burning shale). The primary exploration being undertaken in that area today, however, is for salt mining. This includes efforts to move the major salt mining operations from the outskirts of Yerevan to Aramus. The salt occurs within the middle Miocene section which is directly overlain by upper Miocene sedimentary rocks that contain oil shale beds. The upper part of the section is composed of post-Miocene sedimentary and volcanic rocks. The DUR geologists at the Aramus site believe that the oil shale covers a very large area, approximately 600 km^2. However, the areas which are underlain by the oil shale are either highly populated or used for agricultural purposes, and exploration is hindered considerably by these factors.

There are other oil shale and asphalt deposits known in Armenia (fig. 1). The Aramus area has the advantage over other oil shale-bearing areas because of the extensive subsurface data that was obtained because of salt exploration. Although commercial oil-shale production is very limited on a world-wide basis for economic reasons, and the technology required is not currently available in Armenia, further investigation of the Aramus deposits is warranted by the potentially mitigating effects of simultaneous surface mining of the salt and oil shale deposits. The deposit first needs to be evaluated by standard oil-shale analytical techniques, and the availability of water for oil shale production needs to be investigated. If the results are favorable, engineering feasibility studies for salt and shale coproduction should be considered.

Samples collected at Aramus

The USGS team collected no samples from the Aramus area.

Previous analyses of Aramus Samples

The Aramus oil shales have been the subject of various investigations since the 1950's. Several sets of analytical data performed by Soviet and Armenian laboratories have been obtained by the USGS team. The analyses performed on the oil shale indicate that it contains about 6.4% oil, 16.1% water, 5.6% gas, 69.8% ash, and had a heating value of 2,238 K cal/kg. As previously stated, Fischer Assays or other standard rock-evaluation tests should be conducted and the results reported in gallons of oil yielded per ton.

Makarovite

The Makarovite peat deposits and DUR briquetting plant is located in the north-central part of Armenia (16 on fig. 1). The peat, which is about 2 m thick, fills depressions in the floors of steep-sided valleys in the mountainous region. The age and lateral extent of the peat deposits are unknown. A small peat deposit of about 100,000 m^3 has been completely mined out and stock piled at the briquetting plant. Other peat deposits in the area are currently being mined by farmers for domestic use. Additional peat deposits for future briquetting operations are currently being explored by DUR.

Wet fibrous peat is mixed equally with naturally powdered coal and rock from Idjevan in a mixer/extruder machine that can produce up to 50 tons of briquettes per day. Current daily production ranges from 2 to 15 tons because of the lack of electricity and fuel to operate the plant. The briquettes are extruded as cylinders 8 cm diameter, and about 10 to 15 cm long; they are then loaded onto wooden trays and placed in a drying room which has heated forced air from a large blower located at one end of the room. Another plant, similar in design and production capabilities to the Makarovite plant, has been constructed at Aghrtsin, near the coal mines of Idjevan.

The mixing of Idjevan coal and peat to form briquettes is a very innovative way to maximize the benefits of the two types of solid fuels. The Idjevan coal pulverizes easily and readily mixes with the peat and does not require an additional binding agent to stabilize the briquettes for transport. Immediate increases of heating value could be obtained if the large amount of powdered rock that accompanies the Idjevan coal could be removed prior to briquetting. Immediate increases in briquette production are feasible by increasing the amount of mining at Idjevan and increasing supplies of electricity and fuel to the Makarovite plant. The Djadjur coal could also be mixed with peat to form briquettes and a plan is reportedly underway by the DUR to build such a plant. One very important factor for the future of briquetting depends on the availability of peat. No resource estimates are available for the peat deposits of Armenia and no analytical data are available. If the briquetting operations are to expand, an explorational drilling and sampling program must be initiated to locate and quantify potential resources of peat.

Other peat deposits are known in Armenia, but very little is known about them.

Samples collected at Makarovite

The USGS team collected samples of the dried briquettes, and random samples of the stockpiled peat and Idjevan coal/rock mixture for analyses in USGS laboratories. Bench sampling of the in situ peat deposit was not possible at the time of the team visit.

Previous analyses of Makarovite samples

No previously existing analytical data for the Makarovite peat or briquettes has as yet been acquired by the USGS team.

PLANS FOR THE REMAINDER OF THE PROGRAM

All available information related to the coal-bearing areas of Armenia will be compiled and the coal resource potential of each area will be addressed. This will include collection and organization of all forms of data from the widest variety of sources and will include information about other solid fuel occurrences in Armenia. These efforts will form part of the initial solid fuel data base of the country.

A final report which will contain all data collected and evaluation of the data is under preparation. The USGS team will return to Armenia in early November for about two weeks to discuss the draft final report with counterparts, USAID, and U.S. Embassy representatives, and to reach agreement on conclusions and recommendations. They will return to the U.S.A. for completion of the report.

COUNTERPART ACTIVITIES

It has not been possible in the limited time available to review all the data in the files of the DUR that is relevant to the solid fuel resource potential of Armenia. Much of the data has not been organized and integrated in the forms suitable for entry into an automated data base.

Copies of data required for a preliminary solid-fuel assessment have been partially obtained. Most of the data in Armenia exist only in paper format which is time-consuming to copy by hand and difficult to photocopy because of sporadic availability of electricity.

The DUR will provide copies of requested materials to the extent possible. The data will be available for integration into the final report when the USGS team returns to Armenia in November.

Ideas, suggestions and preliminary recommendations presented in this report will be evaluated and probably modified by counterpart agencies, particularly the DUR.

Training recommendations

The training requirements identified to date fall within two broad categories. The first category is short-term (i.e. weeks to months duration) administrative, scientific and technical training which should include: 1) a review of various management methods for coal exploration, 2) short courses in subject matter related to coal geology, and 3) hands-on training in new or different applied science and technologies related to coal exploration and utilization. The second category is longer-term formal academic training in the areas of basic and applied coal science which generally would require several years duration. Both levels of training would need to include a review of the basic concepts and methodology of resource exploration and evaluation, and would require exposure to state-of-the-art exploration and development practices that are necessary for the utilization of coal in an efficient and environmentally acceptable manner.

Training programs will be outlined in more detail in the final report. Additional training requirements associated with the equipment needs outlined below, will be recognized as the program proceeds.

EQUIPMENT RECOMMENDATIONS

As described in Appendix I, the drilling equipment that was observed by USGS ranges from adequate to well-worn. There is an immediate need for additional pipe, rods, core-barrels, bits, and replacement parts of all kinds. Although the Armenians have become masters of improvisation in order to keep the rigs in operation, adequate replacement supplies are necessary for efficient operations. Support equipment for operation of drill rigs, such as trucks, bulldozers, and jeeps, seems to be well-used and in short supply. Fuel for equipment is the most critical need, and adequate supplies probably would improve overall vehicle availability.

Exploration camp facilities range from acceptable to spartan, and may reflect the individual requirements of the occupants. Most operators would probably benefit from camp improvements.

If expanded activities in coal exploration are to be successful, then coal analytical facilities must be improved greatly. Prior to the dissolution of the Soviet Union, coal analyses were done in the Ukraine or Russia. Since May 1993, organic-matter analyses similar to standard U.S.A. coal analyses have been performed in laboratories of the Armenian State Engineering University (formally the Polytechnic Institute). The methods and standards follow Soviet guidelines for coal analyses, which are adequate. The equipment is old, however, and has been reassembled after removal and transport from various other laboratories in Armenia, and laboratory supplies are scarce. A

general review of the coal analytical laboratory is found in Appendix 1.

PRELIMINARY CONCLUSIONS

The conclusions listed herein are based on the impressions obtained during the month-long visit of the USGS team. Most of these impressions will be modified with the integration and synthesis of additional data and information. These conclusions have not yet been discussed with our Armenian counterparts.

1. There are deposits of usable coal in Armenia.
2. None of the deposits has been studied enough to determine the full extent and complete character of the coal or other solid fuel occurrence.
3. Coal from two localities and peat from one locality are now contributing energy to Armenia. More coal and peat could be produced from these areas and immediately utilized because the coal supply does not meet the demand for the coal.
4. The present-day contribution of coal and other solid fuels to the energy budget of Armenia is comparatively very small. The contribution is significant, however, to those presently dependent upon these fuels, and the contribution could increase in the future if exploration and development studies increase the known coal resource potential.
5. The Armenian government agencies responsible for coal resource development require scientific and technical cooperative assistance and the supplies and equipment necessary to undertake a modern exploration and development program. The scientists and technicians of Armenia are well-trained and competent, but lack experience in the various modern techniques of applied coal geology and coal exploration. Much of the equipment currently being used is wearing out and there is not sufficient fuel and spare parts to operate equipment effectively.

REFERENCES CITED

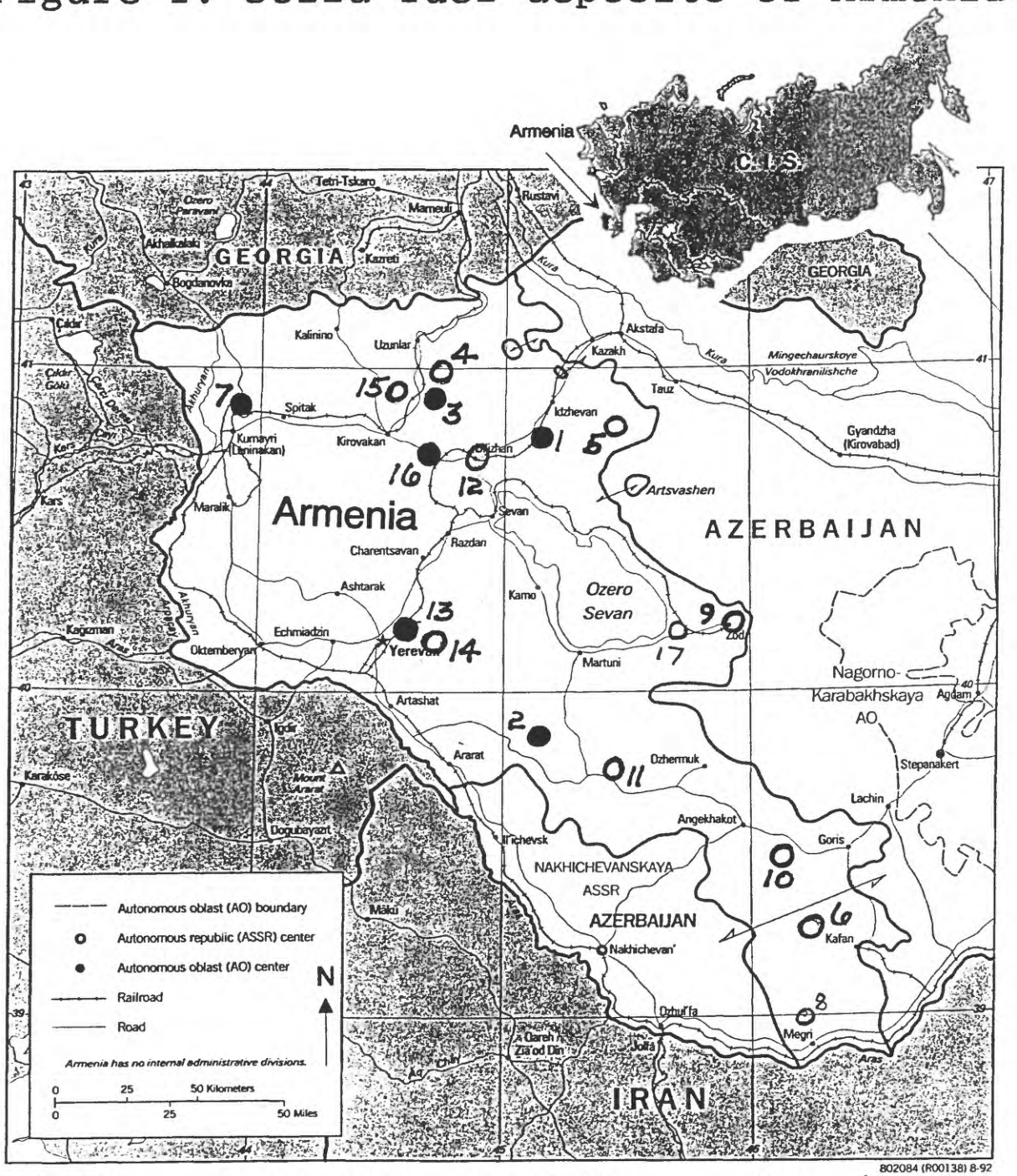
Aslanian, A.T. (ed.), 1984, The Armenian Soviet Socialist Republic Excursions: 010 Neotectonics of Armenia, 102 Permian and Triassic deposits of the Transcaucasus: Moscow, International Geological Congress, XXVII Session, 97 p.

Geoletian, G.G., 1988, Energetika i uglenosnostv nedr respubliki [Energy and coal-bearing underground resources of the Republic]: Nromyshlennot, Ctroitel'ctvo i Arkitekura Armenii [Industry, Construction and Architecture of Armenia]: no. 7, p. 34-38 [in Russian].

Kharajian, H.A., 1915, Regional geology and mining of Armenia: New York, The Nerso Press, 72 p.

Mkrtchyan, K.A., and Martirosyan, S.V., 1975, Ob Idzhevanskom mestorozhdenii kamennykh ugley Armenii [The Idjevan hard coal deposits in Armenia]: Sovetskaia Geologiia, v. 8, p 149-151 [in Russian].

Figure 1. Solid fuel deposits of Armenia.



Hard coal	Brown coal	Oil shale	Peat
1) Idjevan	7) Djadjur	12) Dilijan	16) Markaovite
2) Ghermanis	8) Arevik	13) Aramus	17) Vardanis
3) Shamout	9) Sodk		
4) Antaramut	10) Sisian	Asphalt	
5) Taush	11) Yeghegis	14) Garni	● Site discussed in text
6) Svarants		15) Carnout	

Base map from U.S. Central Intelligence Agency

APPENDIX I
PRELIMINARY REVIEW OF EXPLORATION AND LABORATORY EQUIPMENT CURRENTLY USED FOR COAL EXPLORATION

Drilling equipment

This list of DUR equipment is not complete and consists of equipment observed at the various exploration sites. In general the concentration of DUR's exploration equipment is located at one of the following localities: Idjevan, Djadjur, Djermanis, Shamout, and Aramus. No central store yard was visited by the USGS team and the following list is incomplete.

Idjevan

The DUR geologists have a base camp office, which was not seen by the USGS team. Equipment observed at the bottom of the hill at the coal locality includes four dump trucks (one may be broken); one bulldozer with a track broken; a large tractor with front blade; and one 4X4 Jeep. Equipment at the mine site includes: two trenching back hoes (one broken); one dump truck, one bulldozer; one skid-mounted and one 4X4 truck-mounted drill rig. No drill pipe or spare parts were seen because the rigs were not in place.

Djadjur

The DUR geologists have a small portable building which serves as living and office accommodations. Equipment observed at the mine site include: one truck-mounted drill rig, the truck was obviously not operable so the rig requires towing, no bits or drill pipe were seen; one bulldozer, one back hoe used for mining coal; and several dump trucks which did not belong to DUR.

Djermanis

The DUR geologists have a small portable building which serves as living and office accommodations. Equipment observed at the site includes one bulldozer without a blade, a large generator, one 4X4 truck-mounted rig, and various pieces of mining equipment including a rock cart on tracks.

Shamout

One operable skid-mounted electric-powered drill rig with generator and drill pipe and bits had drilled a hole 185 m deep over the last few months. Rig operation was sporadic due to the shortage of fuel. The drill rig has a potential maximum depth of 450 m.

Aramus

The DUR geologists have a small portable building which serves as living and office accommodations. One operable truck-mounted drill rig with drill pipe and bits had drilled a hole 350 m deep over the last few months. Rig operation was sporadic due to the shortage of fuel.

Coal analytical laboratory equipment

The USGS team visited Professor Azat A. Gulzadian, Chief of the Laboratory of Coal Chemistry, Department of Chemistry and Technology at the Armenian State Engineering University in Yerevan. The laboratory was established in the Spring of 1993 to test coal and oil shale exploration samples for the DUR. Funding for the laboratory is provided by the DUR through a contract to analyze 300 samples during the next 2 years. Twelve people work in the laboratory.

The following review is not meant to be a comprehensive listing of the capabilities of the laboratory, but only a general overview. The laboratory follows published Soviet guidelines for standard coal analytical procedures for coal, peat, and oil shale. Analyses routinely performed by the laboratory include determinations of the percentages of moisture, ash, fixed carbon, volatile matter, humic acids, C, H, N, O, S, forms of S, CO_2, and bitumen content. The laboratory also determines heating values. Other analyses available in the Chemistry Department or other associated laboratories include Free Swelling Indices for coal, and spectral tests on ash and whole coal samples for V, Mo, Be, Ge, Ga, Se, Pb, Mn, Cr, Ni, Cu, and Ti. To date, the Coal Chemistry Laboratory has tested 75 coal samples for the DUR. The total sample process time is about 15 days.

Apparent needs for the Coal Chemistry Laboratory include supplies of laboratory consumables (such as glassware and plastic bags), spare parts for the equipment, and additional equipment including an additional calorimeter, equipment for testing coal plasticity, and a computer for storage and management of analytical results and reports. These recommendations are very preliminary and before any funding is provided to the Coal Chemistry Laboratory, the USGS team recommends that a USGS coal analytical specialist conduct a detailed survey of the equipment and needs and make specific recommendations.

Geophysical logging equipment

The USGS team met briefly with Rafik Mirijanyan, Chief Geophysicist for the DUR. Mr. Mirijanyan explained that the two or three DUR geophysical logging units were used primarily for hard rock/metal and ground water exploration and were rarely used for coal exploration. The last coal drill hole geophysically logged was in Idjevan in the late 1970s. The logging units are truck mounted and have tools for Resistivity, Spontaneous Potential (SP), Natural Gamma, Density, Caliper and Dip Meter. No Neutron or Sonic tools are available. The smallest hole diameter tolerated by the tools is 35 mm. All logging units are analog and there is a 1-2 year supply of spare parts (based on current usage). Spare parts from western sources may be usable as replacements. There are as many as six well-trained geophysicists capable of running the logging equipment. Computers are only used in seismic and magnetic data processing.

The USGS team recommends that every hole drilled for coal in Armenia be geophysically logged. The needs of the DUR Geophysical Department include fuel for the logging trucks and spare parts. Computer upgrades for the logging units would be advisable. The USGS team recommends that a USGS geophysical logging specialist conduct a detailed survey of the equipment and needs and make specific recommendations.