The Nor Arevik Coal Deposit, Southern Armenia

By Brenda S. Pierce, Gourgen Malkhasian, and Artur Martirosyan

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INTRODUCTION

There are six known coal fields in Armenia — Nor Arevik, Antaramut, Shamut, Ijevan, Jermanis, and Jajur (fig. 1) — as well as other minor coal deposits or occurrences. Armenia also contains oil shale deposits at Dilijan, Aramus, Jajur, and Nor Arevik (fig. 1).

The Nor Arevik coal deposit (location 5, fig. 1) is located in southernmost Armenia approximately 15 km north of Megri in the Synik Administrative District. The Nor Arevik coal field is located near the south-flowing Megri River, which is a tributary to the Arax River, which flows along the border between Armenia and Iran. The coal deposit is located between the Megri and Zangezur Mountain Ranges.

SOURCE OF DATA

All data relating to the Nor Arevik coal deposit (stratigraphic, coal quality, and resource information) are contained in this one comprehensive, interpretive report, which is the result of a multiyear study of coal exploration and resource assessment of all the coal deposits in Armenia. Reported here is a synopsis of previously inaccessible data contained either in the State Archives (Fund) of the former U.S.S.R. Ministry of Geology and the current Republic of Armenia's Ministry of Environment Geology Department or the former Soviet and current Republic of Armenia Academy of Sciences. All reports within the State Archives and the Academy of Sciences related to coal in Armenia were obtained, translated, and analyzed. We have supplemented the archival information with some additional data from our earlier published works.

As part of our study of Armenian coals, we built stratigraphic databases of all the coal information from the original archival reports. These stratigraphic databases are reproduced in tabular format (table 1), all data being credited to the original author(s). Additionally, all available coal quality data and coal resource estimates are reported.

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[1] U.S. Geological Survey, 956 National Center, Reston, VA 20192
[2] U.S. Geological Survey Armenian Staff, #5 1st Byway of Aigedzor, Yerevan, Armenia

PREVIOUS WORK

The first regional studies in the Nor Arevik area were conducted as part of a search for copper deposits. Several different workers reported finding coal and carbonaceous shale starting as early as 1869. In 1869, the Nor Arevik deposit was studied by G.G. Tsulukidze, V.A. Arkhipov, and G.V. Khalatov. These workers found only one bed of combustible shale approximately 0.40 m thick. Miller and Denisova (1917) also mentioned the occurrence of coal and combustible shales in the Megri River Basin region, but no specific area was identified.

In the early 1930's, V.A. Shkrabo, a geologist exploring the nearby Jindara copper deposit, also investigated and surveyed the Nor Arevik area. He reportedly found carbonaceous shales, resinous coal, and sandy shales and believed that they were Miocene lacustrine deposits (according to Drobotova and Saponjian, 1996). According to Tarayan (1942), Shkrabo reported a sandy carbonaceous interval as being 70 m thick and noted two coal beds 0.20 and 0.90 m thick. In 1934, V.V. Bogachev studied the Nor Arevik area and found that the shales were similar to those at the Jajur deposit in northwestern Armenia (fig. 1). Bogachev further stated that the Nor Arevik deposits were Pliocene in age, not Miocene, and of no economic interest. Also in the early 1930's, the area was explored by Karpetian and Jerbashian. Both of these workers, independently of each other, stated that the Nor Arevik shales were "bituminous." Paffenholts (1941) estimated the Nor Arevik deposit as being only of local significance.

Although the Nor Arevik coal deposit has been studied since the late 1800's, it is currently reported on in detail in only two internal archival reports: Tarayan (1942) and Drobotova and Saponjian (1996). A subsequent study was done of all coal deposits in Armenia (Pierce and others, 1994).

The first comprehensive study of the Nor Arevik coal deposit was conducted by Tarayan (1942), who dug trenches and shafts (fig. 2). Later, between 1993 and 1996, Drobotova and Saponjian (1996) conducted quite an extensive study for such a small area, including digging trenches and strippings and drilling exploratory boreholes (fig. 2). However, their exploratory effort was directed at finding oil and gas in the region; therefore, in many ways, Tarayan's (1942) much older report is more useful to our purposes.

The Megri Party of the Zangezur Geologic Expedition, as part of Drobotova and Saponjian's (1996) exploratory work, reportedly removed 600 metric tonnes of coal and carbonaceous shale (mine symbol in fig. 2) in 1993 (Pierce and others, 1994). This fuel was used in home heating and in a heating facility in nearby Megri during the energy crisis of 1993.

AGE

Fauna collected by Tarayan (1942) were determined to include *Melanopsis sp*., *Melania sp*., *Trochus sp*., *Phasianella sp*., and *Planorbis sp*., which are gastropods identified at the time as Pliocene. Two of the species were identified as belonging to the *Melanopsis* genus, specifically *M. cf. nobilis Sen*. and *M. cf. acuminata Sen*., which apparently are (or were, in the early 1940's) typical of the Kimmerian stage of the middle Pliocene of Abkhazia. Tarayan (1942) concluded that the age of the Nor Arevik coal deposit was early or middle Pliocene. However, Tarayan (1942) listed other workers who interpreted the fauna or other features (probably lithologic and structural analogy to other dated areas) to be Miocene in age.

Drobotova and Saponjian (1996) stated that the Nor Arevik suite is Neogene in age, specifically late Miocene and early Pliocene. These authors cite two previous studies whose faunal identifications led to this age designation. Drobotova and Saponjian (1996) stated that, in the last century, workers gave a Miocene age on the basis of faunal control, but later collections led workers to give a Pliocene age. Thus, these workers settled on a late Miocene-early Pliocene designation.

STRATIGRAPHIC DATA

The study site covers only about 10 hectares (1 hectare = 100 x 100 m, or 10,000 m^2) (fig. 2). However, Drobotova and Saponjian (1996) expanded the area greatly, stating that the deposit area covers 6 km^2. Great care must be taken in using this areal extent, especially for resource calculations, because recent detailed geologic fieldwork in the area of Nor Arevik (Johnson and others, in review) indicates that this 6 km^2 includes large areas where the stratigraphic unit overlying the coal-bearing unit is known to lie directly on the stratigraphic unit underlying the coal-bearing unit. In other words, this 6 km^2 includes large areas where we know the coal-bearing unit is not present, either having eroded away or never having been deposited. Yet, this area is included in Drobotova and Saponjian's (1996) resource calculations.

The main coal-bearing area, found in figure 2, is a small settlement called Khavot approximately 15 km north of Megri. Most of Tarayan's (1942) and all of Drobotova and Saponjian's (1996) exploratory works were concentrated in this area. Tarayan (1942) also found coal approximately 1 km to the north of Khavot, in two stream drainages, in an area called Getiglykh.

Tarayan (1942) discovered four combustible shale beds in the Getiglykh district, 0.5, 0.45, 0.14, and 0.65 m thick. He also found one coal bed in Getiglykh, 0.12 to 0.14 m in thickness. He described it as good quality coal but thin. In Khavot, Tarayan (1942) described two coal beds ranging from 0.46 to 0.48 m thick. These two beds thin and split toward the north of the Khavot area (fig. 2). In Khavot, Tarayan (1942) found six combustible shale beds having thicknesses ranging from 0.20 to 3.25 m.

The composite coal-bearing section of Tarayan (1942) is 25 m thick and is described as argillo-calcareous-arenaceous rocks containing brown coal and combustible shales. Tarayan's (1942) description of the Nor Arevik combustible shales states that they contain coal beds or lenses, heat when lit by a match, and produce a bitumenlike odor when heated. The combustible shales also burn when put in a fire (hence their name).

Drobotova and Saponjian (1996), on the other hand, never mentioned any occurrence of coal or carbonaceous shale in their report, borehole descriptions, or stratigraphy. Rather, they call their organic interval the deposit's "productive strata," which range from 5.5 to 38.5 m thick. These productive strata, by their description, consist mainly of very dense argillite-siltstone enclosing dark-gray marl layers that contain fauna, black tuffs with opal, and tuffites. In most cases, the productive strata consist of alternating marls, siltstones, and argillites, sometimes supposedly saturated or soaked in bitumen. In fact, some of the descriptive lithologies in the text are actually termed "soak." Occasionally, Drobotova and Saponjian described the "bituminous" parts of their productive strata. On one occasion, they describe "combustible shales" (in quotes) but added in parentheses that these combustible shales are made up of siltstone, tuff, tuffite, and marl.

Usually the terminology "productive" is applied to a coal-bearing or organic horizon of some kind. However, as mentioned before, Drobotova and Saponjian's (1996) work was oriented toward finding oil and gas, and perhaps their ideas led to this "bitumen-soaking" terminology.

Drobotova and Saponjian (1996) believed that they had several sedimentary cycles in this productive strata. They further stated that bitumen was deposited at every cycle change, both in the beginning and in the end. They stated that bitumen occurs as spots, lenticulas, or small layers and as pure bitumen. In some cases, it supposedly occurs with paraffin, which is always confined to the marls. We believe that Drobotova and Saponjian's (1996) "bitumen" is actually coal or combustible shale. They describe the bitumen as black in color, both dull and bright luster. In one place, Drobotova and Saponjian (1996) described three main beds. The third bed (the highest in the section) is a carbonate marl, according to them, and "bituminous," containing interlayers of black, lustrous, almost pure bitumen with yellow sulfur aggregations on the surface. Perhaps this coal is what was observed by other workers. Although we did not examine Drobotova and Saponjian's (1996) core, we have never seen bitumen in any form in any of the outcrops of Nor Arevik. We have seen and sampled coal and carbonaceous shale throughout the deposit but never bitumen.

Drobotova and Saponjian (1996) also reported salt as occurring throughout the strata. We never saw evidence of any salt, nor did Tarayan (1942) report any. There is, however, a great deal of gypsum in the area.

The stratigraphic database, reproduced in table 1, comes from stratigraphic data given by Tarayan (1942) and Drobotova and Saponjian (1996). The exploration works comprise exploration in the form of boreholes, trenches, and shafts but only in a small area. In creating the database, we entered exactly what was contained in the reports as original data, even if we disagreed with the lithology. For example, as described above, nowhere in Drobotova and Saponjian's (1996) lithologies is coal mentioned. In addition, their database contains coal quality analyses for such lithologies as a tuff conglomerate (see for example, 42.5 to 45 m interval in their borehole 4, table 1). However, we kept true to the original authors' lithologic designations in recreating the database, mainly because we would not know what lithologies to substitute. The database has been reformatted for presentation, but all of the data present in the database are reproduced here.

The horizontal exploratory works, such as trenches, are presented here in their original, horizontal descriptions. Because we did not recalculate resources based upon the data given by Tarayan (1942) and Drobotova and Saponjian (1996), we did not reorder the horizontal works to fit into a vertical database. Rather, we simply recreated the data as they appeared in their original works.

Throughout the Soviet Union, an internal system of *x-y* coordinates was used on all working (nonmilitary) maps. This internal coordinate system, as well as the elevation of the particular exploratory work (borehole, shaft, trench), is also found in table 1. Because the studied area is so small, we did not convert this internal coordinate system into latitudes and longitudes. Rather, the relative placement of all exploratory works is found in figure 2. In addition, a complication arose when we compared Tarayan's (1942) and Drobotova and Saponjian's (1996) maps. The two maps, at the same scales, did not "fit." They were offset and we could not match topography or any other clear reference point on the two maps. This lack of fit was another reason for not converting the exploratory works to latitude and longitude.

However, there are some latitude-longitude cross references in the literature. According to Tarayan (1942), the Nor Arevik coal deposit is located at 39° 02' 05" N. and 46° 12' 00" E.; according to Drobotova and Saponjian (1996), the Nor Arevik deposit is located at 39° 02' 05" N.

and 46° 12' 29" E. According to Pierce and others (1994), the southern border of the small strip mine at the site (fig. 2) is located at 39° 01' 21" N. and 46° 12' 29" E.

The geologic map found in figure 2 is modified from Tarayan (1942). The placement of his exploratory trenches and shafts was found on his original map, so we assume that they are correctly placed. However, we placed Drobotova and Saponjian's (1996) exploratory boreholes and shafts on top of Tarayan's (1942) geologic map, so the placement of these later works cannot be considered exact.

COAL QUALITY OF THE NOR AREVIK DEPOSIT

COAL QUALITY ANALYSES

The Armenian government currently reports the Nor Arevik coal deposit as containing six coal beds having an average calorific value of 5988 cal/g and an average ash yield of 14.92 percent (as reported by Pierce and others, 1997).

Pierce and others (1994) took three samples from the small strip mine located on figure 2. These three samples, Meg-1 through Meg-3, are incremental channel samples of the carbonaceous shale and thin coal interbeds at the mine site. Top to bottom, sample Meg-1 is 1.00 m thick, Meg-2 is 0.52 m thick, and Meg-3 is 0.54 m thick. These data (table 2) indicate that the Nor Arevik deposit is a high-ash (47-73 percent, dry basis), high-sulfur (5-7 percent, dry basis) coal or, rather, carbonaceous shale. Data from Tarayan (1942) and some of the stripping samples from Drobotova and Saponjian (1996) (table 2) indicate somewhat lower ash yields, including values as low as 6.50, 13, and 20.11 percent, probably because they took more care in sampling only visibly better quality coal. Borehole data from Drobotova and Saponjian (1996), on the other hand, indicate much higher ash yields (almost all are 70, 80 or 90 percent, table 2) for the "productive strata" of Nor Arevik. It is pointed out again that nowhere in Drobotova and Saponjian's (1996) stratigraphic section, borehole data, or study is coal or carbonaceous shale reported, even though they submitted samples (usually "bitumen" samples) for coal quality analyses and reported on the results of those analyses (tables 1, 2). In the body of their text, Drobotova and Saponjian (1996) reported a calorific value of 3645 to 5695 cal/g, moisture of 0.6 to 16.2 percent, volatile matter ranging from 7.1 to 34 percent, and ash yield between 13.3 and 90.1 percent for their combustible shale resource. These authors also included a data table containing 16 combustible shale samples reporting moisture, ash yield, volatile matter, density, and sulfur (table 3). Drobotova and Saponjian (1996) also reported proximate results as follows: moisture ranging from 0.6 to 16.2 percent; ash yields from 12.3 to 57.6 percent in "bitumen" and from 47.3 to 90.6 percent in the "combustible shales (siltstone, tuff, tuffite, and marl)"; volatile matter ranging from 7.1 to 32.4 percent and in bitumen from 21 to 34 percent; and carbon dioxide contents ranging from 0.5 to 3.3 percent.

The study done in 1869, according to both Tarayan (1942) and Drobotova and Saponjian (1996), gave analytical results on the combustible shales of 67.5 percent combustible mass (that is, 33.5 percent volatile matter) and 32.5 percent ash yield (bases not reported).

Calorific values are quite variable within the Nor Arevik deposit (table 4), but many are relatively high; many samples have values of more than 5,000 cal/g (dry basis). Tarayan (1942) was very careful to separate his samples of coal from samples of combustible shales. The calorific values of his coal samples (approximately 2,500 to almost 7,000 cal/g, dry basis) (table 4) are much higher than calorific values for his combustible shale samples (all but one sample are less than

2,000 cal/g) (table 6). As table 4 shows, Drobotova and Saponjian (1996) had calorific values run for samples. However, exactly what these samples represent is difficult to understand. Drobotova and Saponjian (1996) reported that the Nor Arevik productive strata are comprised of tuffs, siltstones, marls, tuffites, and tuff conglomerates, the heat value of which is due to differences in porosity, sorptive capacity of the rocks, and other factors. Perhaps they are describing what they are calling "bitumen" being absorbed by or adsorbed on these other rocks, although it is unclear. They went on to say that they picked six samples having a 20-percent ash yield, which corresponds to bitumen by composition. The calorific value of this bitumen ranged from 4,581 to 5,695 cal/g, but if the bitumen occurred with paraffin, the heat value increased to 5,042 cal/g (sample #46). If the bitumen occurred with sulfur, the calorific value was the highest at 5,636 to 5,695 cal/g. Four samples also described as bitumen but having siltstone and tuffite partings had a 30-percent ash yield. The calorific values of these samples ranged from 3,645 to 4,635 cal/g.

Drobotova and Saponjian (1996) also had washability analyses performed on 49 samples of the Nor Arevik productive strata (table 2). They stated that 26 of the samples were difficult to wash and that the combustible mass within some of the samples actually decreased after washing. However, after reviewing their data (table 2), we are not so quick to dismiss the washability results. After talking with the chemist who performed the washability analyses, it appears that the samples that were difficult to wash were difficult to wash because of small sample size, not because of some technological difficulty (Arshak Nalbandian, oral communication, 1999). All successfully cleaned samples had much lower ash percentages. In addition, in all but one case, the cleaned samples resulted in increased volatile matters. However, we think that the one sample in which the volatile matter decreased was a mistype. Ash yields were reduced considerably (table 2: 60.6 to 18.7 percent - sample Str-1 #7.5; 34.3 to 14.7 percent - sample Str-1, #28; 61.3 to 19.8 percent - Str-3, #14; and so on) and volatile matters increased considerably (table 2: 19.1 to 41.3 percent; 26.5 to 34.1 percent; 29.9 to 39.1 percent, for the same samples listed above). Thus, if one were interested in using the combustible shales of Nor Arevik, it would be important to know that they are very amenable to cleaning.

Oxide analyses were performed on one of Tarayan's (1942) samples, and the results are as follows (all in percent): $Si0_2$ = 62.59, TiO_2 = 0.08, Al_2O_3 = 20.68, Fe_2O_3 = 9.15, MnO = 0.01, MgO = 0.2, and CaO = 1.91.

Drobotova and Saponjian (1996) also had spectral analyses run on 74 samples, analyzing for 49 elements. Some of their results appear in a table in their report, which is reproduced here in table 5. They reported all results being within Clark norms. However, they stated that nickel, vanadium, zinc, and yttrium were high, and manganese and zirconium were low. These resultant percentages do not, however, appear in their tables, but only as written descriptions in the body of their text.

PETROGRAPHIC DESCRIPTIONS

In thin section, the combustible shales of Nor Arevik, according to Tarayan (1942), are a banded, light brownish-yellow, slightly reddish humic mass having admixtures of finely dispersed clay. He stated that, after petrographic analyses, these shales should really be called "coaly" rather than "combustible." Tarayan (1942) reported that most of these combustible or coaly shales are not sapropelic in origin but that two beds did contain algal material; therefore, these beds do have a sapropelic origin.

According to petrographic results in Tarayan (1942), the lustrous coal is a brown-red humic mass in thin section having inorganic admixtures of very fine quartz, plagioclase, and finely dispersed clay. Ash content within the humic material is 7 to 33 percent. The argillaceous samples have much larger ash contents (45-49 percent). Dull coals contain algal material having much greater admixtures of quartz and plagioclase, ash contents being as high as 52 percent.

OTHER ANALYSES

Tarayan (1942) subjected samples from four beds having thicknesses of 0.50, 0.45, 0.14, and 0.65 m to dry distillation procedures. One of these four beds actually produced 4.5 percent oil at an ash yield of 71 percent. In addition to the oil yielded, all of the samples yielded tar (table 6). Samples yielded as much as 8.8 percent tar. Calorific values reached up to 2,254 cal/g for these combustible shales. Tarayan (1942) stated that the tar yield and calorific value are directly proportional (that is, increase in tar yield increases the shale's calorific value):

Tar yield (percent)	Calorific value (cal/g)
2.4	1065
4.0 - 4.8	1235 - 1272
6.0 - 6.4	1,529 - 1,566
6.8	1837
8.8	2254

Tarayan (1942) gave general uses for the combustible shales of the Nor Arevik deposit, including direct use as fuels because of their calorific values (as high as 1,700 cal/g, dry basis) and as raw materials in a dry distillation process for the production of tar and subsequent distillation of the tar for different "petroleum" products. The calorific value stated in the previous sentence is only for the combustible shales. As discussed above, when Tarayan chose only coal samples, the calorific values were much higher.

Drobotova and Saponjian (1996) submitted nine samples to an oil laboratory, which analyzed for moisture, ash, carbon, sulfur, organic carbon, and humic acid and conducted luminescent analysis (table 7). Moisture and ash yield results agreed with those found in table 2, discussed above. Organic carbon ranged from 1.7 to 6.05 percent. Little humic acid was produced (only 0.08-0.14 percent). The type of bitumen yielded from the samples was either tar bitumen A or tar-asphaltene bitumen A, in accordance with GOST (Soviet State Standard). The resultant percentages of these bitumens ranged only from 0.235 to 1.25 percent (table 7).

Drobotova and Saponjian (1996) then calculated bitumen ratios on their nine samples by using the following formula: (CB/C_{org}) x 100 percent = bitumen ratio (where CB = chloroform bitumen and C_{org} = organic carbon). They stated that the results ranged from relatively high (6.85 percent) to very high (25.46 percent), characterizing their strata as very unevenly saturated in bitumen. These authors interpreted a high bitumen ratio and a high organic carbon content as indicative of "oil saturation." However, it must be kept in mind that these are only ratios and that the percentage of actual bitumen yield was very low.

According to Drobotova and Saponjian (1996), citing GOST-GK3, the rocks of the productive horizon belong to the group described as asphalt shale (the "fifth group" in the GOST classification): asphalt shale, rock that is full of oil, and the organic material consisting of much ready bitumen or completely formed from bitumen. Six of Drobotova and Saponjian's (1996) samples contained 20 percent ash; they classified these samples as bituminous on the basis of calorific values ranging from 4,581 to 5,695 cal/g.

Further, according to Drobotova and Saponjian (1996), by GOST Standard 7754-89 (the pre-Baltic carbonaceous shales classifications), the Nor Arevik shale results are greater than the pre-Baltic carbonaceous shale results. Therefore, their conclusion is that Nor Arevik fuel has a very large future for fuel as bitumen.

Drobotova and Saponjian (1996) used the carbon, hydrogen, nitrogen, and sulfur results from three Nor Arevik samples from Pierce and others (1994) (table 8) to show that these samples should be oil producing according to the C:H ratios. Drobotova and Saponjian (1996) calculated a metamorphic indicator (Kc) using fixed carbon divided by fixed carbon plus volatile matter. By using this degree of metamorphism, these authors believed that they could compare ash-free coke to ash-free coal. They stated that if Kc is greater 70 percent, then no oil is possible; if the numbers are less than 70 percent, then oil should occur in the samples. In this case, their calculated Kc values were equal to 43 percent, 32.8 percent, and 25 percent; therefore they concluded that oil should be present in these samples.

In addition to all of these other analyses, Drobotova and Saponjian (1996) took nine gross samples ranging from 250 kg to 3.0 tons (totaling 8 tons) for testing in nearby heating facilities. The samples were crushed to 5x3x2 cm. Before burning, a high temperature was attained by burning wood in the furnace. Burning eight of the samples produced ash residues that ranged from 46 to 88 percent by volume of burnt material and 26 to 66 percent by weight. Anecdotally, the authors stated that the coal emitted considerable "poisonous gas and soot" and that the room smelled of bitumen and sulfur. However, one sample was burned in a home/office stove and the results of this small test were apparently successful: the stove was red hot and the air was clean.

COAL RESOURCE CALCULATIONS OF THE NOR AREVIK DEPOSIT

RESOURCE TERMINOLOGY

The methods used in the United States and the former Soviet Union for calculating and reporting coal resource and reserve tonnage are very similar (Pierce and others, 1996). The system used in the United States was developed at the U.S. Geological Survey (USGS) (Wood and others, 1983) and the former U.S. Bureau of Mines. The system currently used in many of the members of the Commonwealth of Independent States was developed by the Ministry of Geology of the former U.S.S.R. Both systems classify coal resources and reserves on the basis of the degree of geologic control and economic feasibility of recovery. Both systems have mechanisms for exclusions that are based on ash yield, depth, bed thickness, and parting thickness.

Both systems are based on the distribution and spacing of known data. As a result, both systems have reporting categories that refer to the degrees of confidence or uncertainty. In the USGS system, the resource reliability categories are termed "measured," "indicated," "inferred," and "hypothetical"; in the U.S.S.R. Ministry of Geology system, the categories are termed "A," "B," "C_1," "C_2," and "P_1 and P_2." The USGS "measured" equates to the Soviet "A" + "B," "indicated" is the same as "C_1," "inferred" is correlative to "C_2," and "hypothetical" is

equivalent to "P_1" and "P_2." Each resource or reserve category is dependent on the density of the exploration network. These categories are directly dependent on their distance from known data points, either coal in boreholes or in outcrop; each category increases the distance from known coal localities and correlatively decreases the certainty with which the tonnage estimate is given.

ARCHIVAL RESOURCE ESTIMATES

Current resource estimates for the Nor Arevik deposit, given by the Armenian Government (unpublished data), calculated on six beds are as follows: 22,500 metric tonnes of C_2 coal, 228,200 metric tonnes of C_1 combustible shale, and 127,400 metric tonnes of C_2 combustible shale. These numbers are most likely derived from work done by Tarayan in the early 1940's.

Tarayan (1942) was the first to calculate resource tonnage for the Nor Arevik coal and carbonaceous shale deposit (tables 9, 10). He stated that the grid spacing of his data allowed for categorization of resources into the categories of B and C. However, because he did not complete the required quality analyses on the combustible shales to warrant these category designations, he downgraded his categories accordingly. Tarayan used a density of 1.4 g/cm^3 for his coal resource calculations and a density of 1.8 or 1.9 g/cm^3 for his combustible shale resource calculations.

Tarayan (1942) calculated resources for the Khavot area only; he did not extend nor correlate his coal or carbonaceous shale beds from Khavot to Getiglykh. His carbonaceous shale resources total approximately 500,000 metric tonnes (table 10). "Expectant" resources, according to Tarayan, to a depth of 300 m are equal to approximately 3 million metric tonnes. Although he did not use the terminology, these resources must be hypothetical. Tarayan's (1942) coal resources equal only 22,285 metric tonnes (table 9) because he took great care in separating coal from carbonaceous shale. Together, his total resources for the Nor Arevik deposit, of $C_1 + C_2$ coal and carbonaceous shale, equal 521,132 metric tonnes.

Drobotova and Saponjian (1996) undertook a more recent study to reestimate the deposit's resources. According to Drobotova and Saponjian's (1996) synopsis, they dug 4533.7 m^3 of strippings, five shafts, and eight boreholes (totaling 383 m, the maximum depth of a borehole being 70 m) on a 100 x 100 m grid. Although they did not list carbonaceous or combustible shale as a lithology in their borehole descriptions or report, they did calculate resources for the combustible shales of Nor Arevik (table 11). They stated, in the resource calculation section, that the highly bituminous combustible shales are very nonpersistent and rapidly pinch out along dip. Thus they calculated the combustible shale resources together with the other members of the productive strata, represented by siltstones, tuffites, marls, and tuffs. According to these authors, combustible shale resources (for pulverized combustion) were calculated at 1,814,895 metric tonnes of C_1 category combustible shale and 410,303 metric tonnes of category C_2 shale, for a total of 2,225,198 metric tonnes of combustible shale in the Nor Arevik deposit. However, the C_1 and C_2 category resources are highly suspect because the tonnage figures contain lithologies such as siltstones, tuffs, and marls.

Drobotova and Saponjian (1996) stated that their P_1 (hypothetical) resources for their Nor Arevik productive beds were calculated for an area of approximately 6 km^2. Further, the productive horizon in this larger area can be 300 to 700 m deep. They used a thickness of 21.2 m and a density of 2.6 g/cm^3 for their hypothetical resource calculation. They calculated 65,631,400 metric tonnes of P_1 (hypothetical) combustible shale for the Nor Arevik deposit. However, as discussed

before, because this areal extent is highly suspect, these hypothetical tonnage figures must also be suspect.

RECALCULATION OF RESOURCE ESTIMATES

An attempt was made to correlate the stratigraphic data of Tarayan (1942) with that of Drobotova and Saponjian (1996) in order to give resource estimates based on the work presented in both reports. However, because Tarayan (1942) had no borehole data, (his data were all surficial) and because we could not be sure which of the lithologies of Drobotova and Saponjian (1996) were really coal and(or) combustible shale — and consequently what they used in their resource calculations — we believed that to recalculate any kind of resources was fruitless. Further, because the Khavot area is small, additional data are not necessarily needed to recalculate its resources. Because other lithologies were included in Drobotova and Saponjian's (1996) C_1 and C_2 category calculations and because large areas are believed not to contain any coal or carbonaceous shale in their hypothetical calculations, we consider Tarayan's (1942) resource tonnage to be more reliable.

CONCLUSIONS

The Nor Arevik coal deposit covers a very small area, approximately only 10 ha. This deposit is composed more of carbonaceous or combustible shale than of coal. However, for a local resource, this deposit could be important. The Nor Arevik coal and combustible shale has been used in home heating and a district heating facility in nearby Megri, apparently with some success. In addition, it cleans very well, the results being increased volatile matter and decreased ash yields. Tarayan's (1942) resource estimates are probably the best to date and are also close to the Armenian Government's officially reported tonnage. Therefore, we consider the best current resource estimates for the Nor Arevik coal deposit to be the following: 22,285 metric tonnes of coal and 498,847 metric tonnes of combustible shale, for a total resource of 521,132 metric tonnes of coal and combustible shale.

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Figure 1. Location of coal, carbonaceous shale, and oil shale deposits in Armenia.

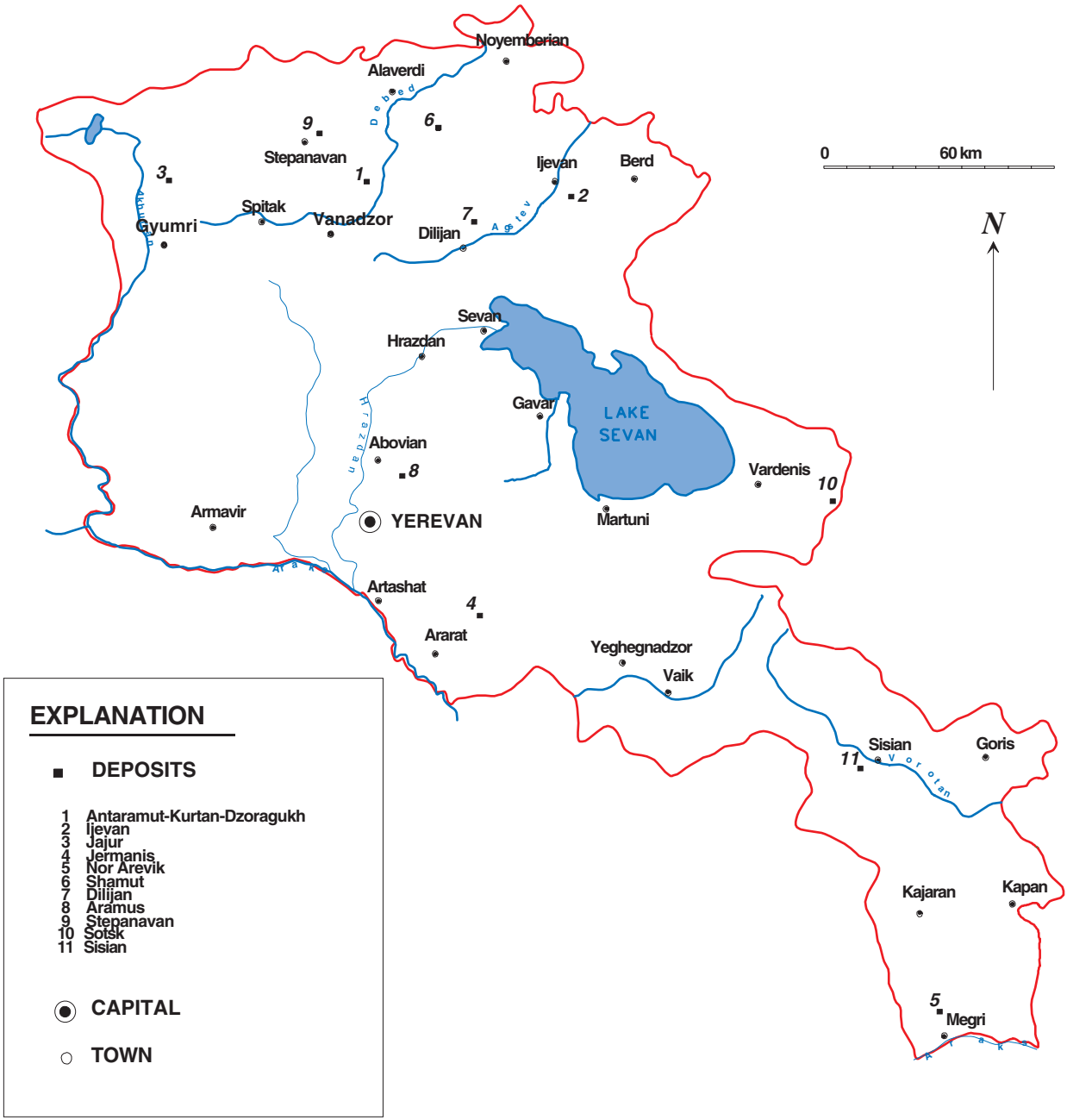
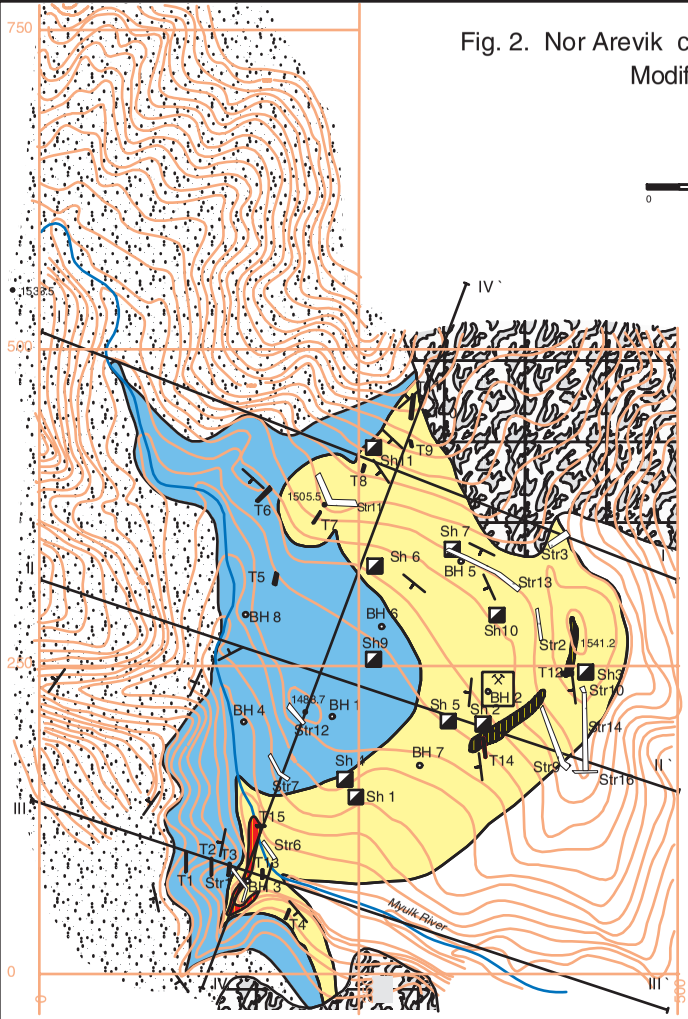


Fig. 2. Nor Arevik coal and carbonaceous shale deposit.
Modified from Tarayan (1942).



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EXPLANATION

- Modern sediments
- Conglomeratic breccia
- Coarse grained sandstone
- Coal-bearing and carbonaceous shale-bearing strata
- Carbonaceous shale outcrop
- Granodiorite
- Strike and dip
- Trenches and shafts (by Tarayan, 1942)
- BH-8 — Boreholes drilled in 1993-96 (by Drobotova and Saponjian, 1996)
- Mine workings (Drobotova and Saponjian, 1996)
- Strippings (Drobotova and Saponjian, 1996)

Geological Cross Sections

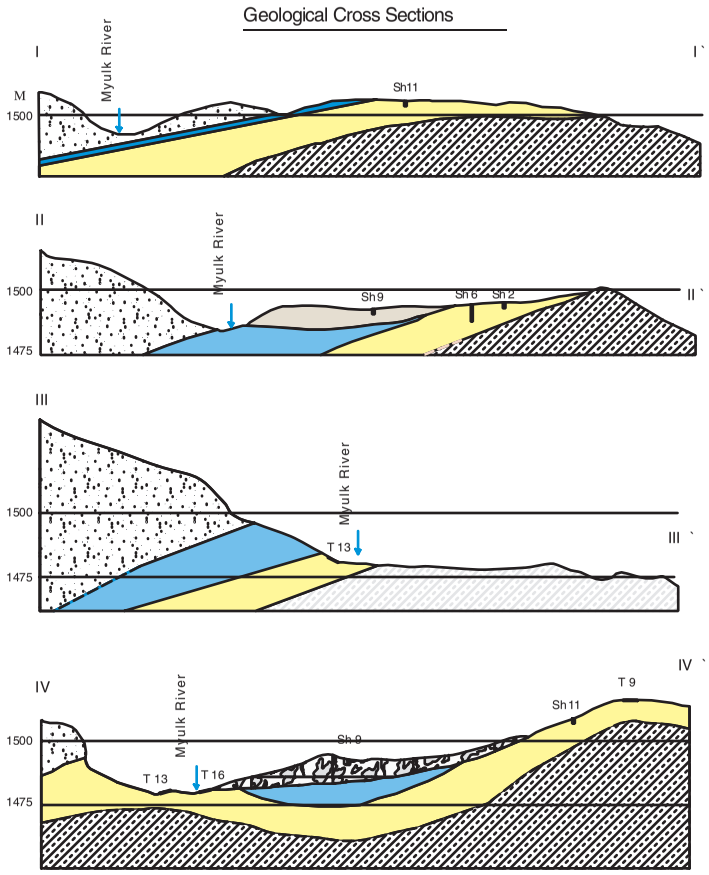

Table 1. Borehole, adit, and trench data from exploration done by Tarayan (1942) and Drobotova and Saponjian (1996) on the Nor Arevik coal deposit

[Exploratory works labeled number/41 are from Tarayan (1942); works labeled number/96 are from Drobotova and Saponjian (1996). Top and bottom intervals are in meters. Reporting bases of coal quality data is not known. ID, identifier; Elev, elevation; N coord, north coordinate; E coord, east coordinate; Btm, bottom; M, moisture; A, ash yield; VM, volatile matter; TS, total sulfur; d, density; (PS), productive strata of Drobotova and Saponjian (1996); Str, stripping]

Point ID	Elev (m)	N coord	E coord	Top (m)	Btm (m)	Lithology	M (percent)	A (percent)	VM (percent)	TS (percent)	d (g/cm^3)
Borehole 1/96	1482	200	230	0	0.8	Loam					
				0.8	8	Sand					
				8	9.5	Clay					
				9.5	15	Clay with sooty material					
				15	20	Clay					
Borehole 2/96	1481.2	250	362.5	0	0.8	Silt with bitumen (PS)	4.1	47.3	27.3		
				0.8	4	Argillaceous siltstone with bitumen (PS)	4.2	58.2	22.2		
				4	8	Argillaceous siltstone with bitumen (PS)	2.7	54.6	26.7		
				8	10	Argillaceous siltstone with bitumen (PS)	2	64.4	27		

Table 1. Borehole, adit, and trench data from exploration done by Tarayan (1942) and Drobotova and Saponjian (1996) on the Nor Arevik coal deposit—Continued

Point ID	Elev (m)	N coord	E coord	Top (m)	Btm (m)	Lithology	M (percent)	A (percent)	VM (percent)	TS (percent)	d (g/cm^3)
Borehole 2/96				10	12.8	Argillaceous siltstone with bitumen (PS)	3.6	77.8	15.9		
				12.8	39	Tuffite					
				39	50	Tuff breccia					
Borehole 3/96	1459	76	195	0	0.1	Soil					
				0.1	0.6	Argillaceous siltstone with bitumen (PS)	4.6	78.7	16.9		
				0.6	1.2	Argillaceous siltstone with bitumen (PS)	4.2	81	13.5		
				1.2	3.5	Argillaceous siltstone with bitumen (PS)	0.6	82.7	14.3		
				3.5	5.5	Argillaceous siltstone with bitumen (PS)	0.8	85.5	13.1		
				5.5	20.8	Breccia					
				20.8	29	Conglomerate					
Borehole 4/96	1467	192.5	180	0	2.7	Loam					
				2.7	5.6	Tuffite (PS)					

Table 1. Borehole, adit, and trench data from exploration done by Tarayan (1942) and Drobotova and Saponjian (1996) on the Nor Arevik coal deposit—Continued

Point ID	Elev (m)	N coord	E coord	Top (m)	Btm (m)	Lithology	M (percent)	A (percent)	VM (percent)	TS (percent)	d (g/cm^3)
Borehole 4/96				5.6	5.8	Tectonically broken rock (PS)					
				5.8	8.8	Tuffite (PS)					
				8.8	12	Argillite with bitumen (PS)	3.3	87.9	11.4		
				12	13.7	Argillite with bitumen (PS)	2.3	92.4	7.1		
				13.7	14.7	Clay (PS)	2.5	90.1	8.3		
				14.7	17	Argillaceous siltstone with bitumen (PS)	2.4	88.7	9.3		
				17	19	Marl siltstone with bitumen (PS)	0.7	84.7	12.5		
				19	22	Marl siltstone with bitumen (PS)	2.6	76.1	18.8		
				22	24	Marl siltstone with bitumen (PS)	3.2	76.8	17.6		
				24	27	Marl siltstone with bitumen (PS)	1.4	76.4	16.8		

Table 1. Borehole, adit, and trench data from exploration done by Tarayan (1942) and Drobotova and Saponjian (1996) on the Nor Arevik coal deposit—Continued

Point ID	Elev (m)	N coord	E coord	Top (m)	Btm (m)	Lithology	M (percent)	A (percent)	VM (percent)	TS (percent)	d (g/cm^3)
Borehole 4/96				27	30	Marl siltstone with bitumen (PS)	3.4	80.6	14.5		
				30	32	Marl siltstone with bitumen (PS)					
				32	34.5	Marl siltstone with bitumen (PS)	2.7	80.3	16.5		
				34.5	36	Clay (PS)	4	80	15.5		
				36	37	Marl siltstone with bitumen (PS)	3.5	82.7	12.7		
				27	38	Tuffite (PS)	1.5	76.4	17.2		
				38	40	Marl siltstone with bitumen (PS)	0.9	81	16.2		
				40	42.5	Siltstone (PS)	1	83.7	13.8		
				42.5	45	Tuff conglomerate (PS)	1.1	86.5	11.1		

Table 1. Borehole, adit, and trench data from exploration done by Tarayan (1942) and Drobotova and Saponjian (1996) on the Nor Arevik coal deposit—Continued

Point ID	Elev (m)	N coord	E coord	Top (m)	Btm (m)	Lithology	M (percent)	A (percent)	VM (percent)	TS (percent)	d (g/cm^3)
Borehole 4/96				45	46	Argillaceous tuff siltstone with bitumen (PS)	2.5	83.5	13.3		
				46	47.7	Argillaceous tuff siltstone with bitumen (PS)	2.9	58.9	21.5		
				47.7	50	Tuffite, tuff conglomerate, and tuff sandstone	2.7	89.7	7.7		
				50	63	Tuffite, tuff conglomerate, and tuff sandstone					
				63	64.8	Intrusive					
				64.8	68	Tuff breccia					
Borehole 5/96	1499	332.5	327.5	0	0.5	Clay					
				0.5	4	Marl					
				4	5	Argillaceous siltstone with bitumen (PS)	4.5	78.2	15.7		

Table 1. Borehole, adit, and trench data from exploration done by Tarayan (1942) and Drobotova and Saponjian (1996) on the Nor Arevik coal deposit—Continued

Point ID	Elev (m)	N coord	E coord	Top (m)	Btm (m)	Lithology	M (percent)	A (percent)	VM (percent)	TS (percent)	d (g/cm^3)
				5	8	Argillaceous siltstone with bitumen (PS)	3.5	72.9	20.8		
				8	10	Argillaceous siltstone with bitumen (PS)	4.1	81.3	15.1		
Borehole 5/96				10	12	Argillaceous siltstone with bitumen (PS)	0.7	76	17.8		
				12	14	Argillaceous siltstone with bitumen (PS)	1.6	79.1	16.8		
				14	17	Argillaceous siltstone with bitumen (PS)	3.6	80.2	14.6		
				17	17.4	Tuffite (PS)	4	82.6	15.7		
				17.4	20	Argillaceous siltstone with bitumen (PS)					
				20	21	Argillaceous siltstone with bitumen (PS)	2.7	80.3	15.4		
				21	24.8	Tuffite					
				24.8	25.2	Limestone					
				25.2	26.8	Tuffite					

Table 1. Borehole, adit, and trench data from exploration done by Tarayan (1942) and Drobotova and Saponjian (1996) on the Nor Arevik coal deposit—Continued

Point ID	Elev (m)	N coord	E coord	Top (m)	Btm (m)	Lithology	M (percent)	A (percent)	VM (percent)	TS (percent)	d (g/cm^3)
Borehole 5/96				26.8	27.4	Marl					
				27.4	30	Argillaceous siltstone with bitumen (PS)	2.9	83.2	12.8		
				30	33	Argillaceous siltstone with bitumen (PS)	2.2	83.3	11.8		
				33	35	Argillaceous siltstone with bitumen (PS)	3.7	82.8	13		
				35	36	Argillaceous siltstone with bitumen (PS)	2.5	83.9	13.4		
				36	36.2	Chloritic rocks					
				36.2	39	Conglomerate breccia					
				39	56	Chloritic rocks					
				56	57	Limestone with fauna					
Borehole 6/96	1487	272.5	262.5	0	6	Loam					
				6	6.5	Clay					
				6.5	8.5	Marl	4	77.2	18.1		

Table 1. Borehole, adit, and trench data from exploration done by Tarayan (1942) and Drobotova and Saponjian (1996) on the Nor Arevik coal deposit—Continued

Point ID	Elev (m)	N coord	E coord	Top (m)	Btm (m)	Lithology	M (percent)	A (percent)	VM (percent)	TS (percent)	d (g/cm^3)
Borehole 6/96				8.5	10	Marl siltstone with bitumen (PS)	1.8	73.2	20.8		
				10	13	Marl siltstone with bitumen (PS)	1.1	75.9	17.1		
				13	15	Marl siltstone with bitumen (PS)	4.1	80.2	14.1		
				15	16.5	Marl siltstone with bitumen (PS)	3.8	83	14.1		
				16.5	18	Marl siltstone with bitumen (PS)	3.7	79.5	16.3		
				18	19.5	Marl siltstone with bitumen (PS)	4.3	81.5	12.4		
				19.5	20	Tuffite					
				20	21	Marl siltstone with bitumen (PS)	3.8	80	17.3		
				21	24	Marl siltstone with bitumen (PS)	4.1	81.9	14.5		

Table 1. Borehole, adit, and trench data from exploration done by Tarayan (1942) and Drobotova and Saponjian (1996) on the Nor Arevik coal deposit—Continued

Point ID	Elev (m)	N coord	E coord	Top (m)	Btm (m)	Lithology	M (percent)	A (percent)	VM (percent)	TS (percent)	d (g/cm^3)
Borehole 6/96				24	25	Marl siltstone with bitumen (PS)	4.6	81.4	15		
				25	28	Tuffite					
				28	30	Marl siltstone with bitumen (PS)	4.7	82.1	15.1		
				30	33	Marl siltstone with bitumen (PS)	3.5	85.8	11.5		
				33	34	Marl siltstone with bitumen (PS)	4.2	86.4	9.8		
				34	35	Marl siltstone with bitumen (PS)	0.9	82.2	13.1		
				35	44	Tuffite					
Borehole 7/96	1419	192.5	292.5	0	2.2	Loam					
				2.2	4.8	Clay					
				4.8	6.5	Argillaceous siltstone with bitumen (PS)					
				6.5	9	Argillaceous siltstone with bitumen (PS)					

Table 1. Borehole, adit, and trench data from exploration done by Tarayan (1942) and Drobotova and Saponjian (1996) on the Nor Arevik coal deposit—Continued

Point ID	Elev (m)	N coord	E coord	Top (m)	Btm (m)	Lithology	M (percent)	A (percent)	VM (percent)	TS (percent)	d (g/cm^3)
Borehole 7/96				9	11.2	Argillaceous siltstone with bitumen (PS)					
				11.2	12.5	Tuff breccia					
				12.5	14.5	Marl siltstone with bitumen (PS)					
				14.5	17	Tuff breccia					
				17	19.9	Marl siltstone with bitumen (PS)					
				19.9	20.3	Tuff breccia					
				20.3	21	Marl siltstone with bitumen (PS)	4.2	87.8	9.3		
				21	36.8	Tuffite					
				(24.5)	(25.8)		3.7	86.4	9.9		
				(30.0)	(33.0)		2.8	79.5	14.9		
				(38.0)	(40.5)		3.3	84.8	11.9		
				(41.0)	(43.0)		2.6	77.8	18.4		
				(43.0)	(46.0)		1.5	78.7	11.6		
				36.8	45	Tuff breccia					

Table 1. Borehole, adit, and trench data from exploration done by Tarayan (1942) and Drobotova and Saponjian (1996) on the Nor Arevik coal deposit—Continued

Point ID	Elev (m)	N coord	E coord	Top (m)	Btm (m)	Lithology	M (percent)	A (percent)	VM (percent)	TS (percent)	d (g/cm^3)
Borehole 8/96	1482	280	172	0	15	Sandy argillaceous rocks					
				15	24.5	Tuffite					
				24.5	25.8	Marl siltstone with bitumen (PS)	3.7	86.4	9.9		
				25.8	26.1	Marl siltstone with bitumen (PS)					
				26.1	28	Marl siltstone with bitumen (PS)					
				28	30	Marl siltstone with bitumen (PS)					
				30	33	Marl siltstone with bitumen (PS)	2.8	79.5	14.9		
				33	36	Marl siltstone with bitumen (PS)					
				36	38	Marl siltstone with bitumen (PS)					

Table 1. Borehole, adit, and trench data from exploration done by Tarayan (1942) and Drobotova and Saponjian (1996) on the Nor Arevik coal deposit—Continued

Point ID	Elev (m)	N coord	E coord	Top (m)	Btm (m)	Lithology	M (percent)	A (percent)	VM (percent)	TS (percent)	d (g/cm^3)
Borehole 8/96				38	40.5	Marl siltstone with bitumen (PS)	3.3	84.8	11.9		
				40.5	41	Marl siltstone with bitumen (PS)					
				41	43	Marl siltstone with bitumen (PS)	2.6	77.8	18.4		
				43	46	Marl siltstone with bitumen (PS)	1.5	78.7	11.6		
				46	48	Marl siltstone with bitumen (PS)	3.5	69.9	15.4		
				48	51	Marl siltstone with bitumen (PS)	3.3	83.8	14.6		
				51	54	Marl siltstone with bitumen (PS)	4.6	85.8	10.8		
				54	56	Marl siltstone with bitumen (PS)					

Table 1. Borehole, adit, and trench data from exploration done by Tarayan (1942) and Drobotova and Saponjian (1996) on the Nor Arevik coal deposit—Continued

Point ID	Elev (m)	N coord	E coord	Top (m)	Btm (m)	Lithology	M (percent)	A (percent)	VM (percent)	TS (percent)	d (g/cm^3)
Borehole 8/96				56	58	Marl siltstone with bitumen (PS)	3.1	82.8	14		
				58	60	Marl siltstone with bitumen (PS)	3.6	73.8	15		
				60	62.4	Marl siltstone with bitumen (PS)					
				62.4	63	Marl siltstone with bitumen (PS)					
				63	63.5	Chloritic rocks	1.2	89.6	9.8		
				63.5	65	Chloritic rocks	0.8	91	6.5		
				65	70	Chloritic rocks					
Shaft 1 (Str-2)/96	1497.5	262.5	375	0	1	Sandy shale					
Shaft 1/41	1472	142.5	245	0	0.65	Loam					
				0.65	1.65	Sandy loam with gravel					
Shaft 10/41	1496	282.5	352.5	0	0.1	Diluvium					
				0.1	1.7	Clay					

Table 1. Borehole, adit, and trench data from exploration done by Tarayan (1942) and Drobotova and Saponjian (1996) on the Nor Arevik coal deposit—Continued

Point ID	Elev (m)	N coord	E coord	Top (m)	Btm (m)	Lithology	M (percent)	A (percent)	VM (percent)	TS (percent)	d (g/cm^3)
Shaft 10/41				1.7	1.81	Combustible shale					
				1.81	1.95	Clay					
				1.95	2.01	Combustible shale					
				2.01	2.03	Clay					
				2.03	2.1	Combustible shale					
				2.1	2.42	Clay					
				2.42	3.09	Combustible shale					
				3.09	3.16	L:imestone					
				3.16	3.41	Clay					
				3.41	3.42	Coal					
				3.42	4.25	Limestone					
				4.25	4.29	Coal					
				4.29	4.76	Limestone					
				4.76	4.98	Coal	5.7	20.2	38.4		
				4.98	5.11	Limestone with fauna					
				5.11	5.26	Coal					

Table 1. Borehole, adit, and trench data from exploration done by Tarayan (1942) and Drobotova and Saponjian (1996) on the Nor Arevik coal deposit—Continued

Point ID	Elev (m)	N coord	E coord	Top (m)	Btm (m)	Lithology	M (percent)	A (percent)	VM (percent)	TS (percent)	d (g/cm^3)
Shaft 10/41				5.26	5.28	Clay					
				5.28	5.38	Combustible shale					
				5.38	5.4	Clay					
				5.4	5.55	Combustible shale					
Shaft 11/41	1515	405	257	0	0.08	Limestone					
				0.08	0.1	Coaly limestone					
				0.1	0.26	Limestone with fauna					
				0.26	0.28	Coal					
				0.28	0.32	Limestone					
				0.32	0.33	Coal					
				0.33	0.37	Limestone					
				0.37	0.38	Coal					
				0.38	0.49	Limestone					
				0.49	0.66	Coal					
				0.66	0.68	Limestone with fauna					
				0.68	0.74	Coal					

Table 1. Borehole, adit, and trench data from exploration done by Tarayan (1942) and Drobotova and Saponjian (1996) on the Nor Arevik coal deposit—Continued

Point ID	Elev (m)	N coord	E coord	Top (m)	Btm (m)	Lithology	M (percent)	A (percent)	VM (percent)	TS (percent)	d (g/cm^3)
Shaft 11/41				0.74	0.76	Coaly limestone					
				0.76	0.77	Coal					
				0.77	0.86	Coaly limestone					
				0.86	0.9	Soot					
				0.9	0.92	Coal					
				0.92	0.98	Combustible shale					
				0.98	1.14	Clay					
				1.14	1.55	Combustible shale					
				1.55	1.7	Clay					
				1.7	1.74	Combustible shale					
				1.74	1.75	Clay					
				1.75	3.9	Combustible shale					
Shaft 2 (Str 4)/96	1515.5	410	250	0	0.3	Clay					
				0.3	1	Sandy shale					
Shaft 2/41	1487	200	342.5	0	0.25	Diluvium					

Table 1. Borehole, adit, and trench data from exploration done by Tarayan (1942) and Drobotova and Saponjian (1996) on the Nor Arevik coal deposit—Continued

Point ID	Elev (m)	N coord	E coord	Top (m)	Btm (m)	Lithology	M (percent)	A (percent)	VM (percent)	TS (percent)	d (g/cm^3)
Shaft 2/41				0.25	0.48	Combustible shale with coal lenses					
				0.48	0.52	Coal					
				0.52	0.92	Combustible shale					
Shaft 3 (Str 5)/96	1506	337.5	407.5	0	3.8	Clay					
				3.8	4	Sandy shale					
Shaft 3/41	1507	237.5	422.5	0	0.15	Soil					
				0.15	1.6	Clay					
				1.6	2	Limestone					
				2	4.8	Clay with combustible shale					
				4.8	5	Limestone					
				5	6.05	Combustible shale					
				6.05	6.4	Coaly clay					
Shaft 4/41	1476	160	240	0	1.2	Loam					
Shaft 5/41	1486	207.5	325	0	1.5	Loam					
				1.5	2.3	Clay					

Table 1. Borehole, adit, and trench data from exploration done by Tarayan (1942) and Drobotova and Saponjian (1996) on the Nor Arevik coal deposit—Continued

Point ID	Elev (m)	N coord	E coord	Top (m)	Btm (m)	Lithology	M (percent)	A (percent)	VM (percent)	TS (percent)	d (g/cm^3)
				2.3	2.6	Combustible shale					
				2.6	2.72	Clay with coal lenses					
				2.72	2.95	Combustible shale					
				2.95	3.05	Clay					
				3.05	3.12	Combustible shale					
				3.12	3.35	Limestone					
				3.35	3.38	Coal					
				3.38	3.85	Limestone with fauna					
				3.85	3.95	Coaly clay					
				3.95	5.25	Coal	5.7	49.5	27.2	8.2	1.8
				5.25	5.68	Coal	4	52	25.5	6.1	1.8
				5.68	5.84	Limestone					
				5.84	7.1	Combustible shale					
Shaft 6/41	1494	320	287.5	0	1.1	Diluvium					
				1.1	1.7	Loam with gravel					

Table 1. Borehole, adit, and trench data from exploration done by Tarayan (1942) and Drobotova and Saponjian (1996) on the Nor Arevik coal deposit—Continued

Point ID	Elev (m)	N coord	E coord	Top (m)	Btm (m)	Lithology	M (percent)	A (percent)	VM (percent)	TS (percent)	d (g/cm^3)
Shaft 6/41				1.7	2.22	Clay with coal					
				2.22	2.78	Clay					
				2.78	3.15	Combustible shale					
				3.15	3.23	Clay					
				3.23	3.44	Combustible shale					
				3.44	3.5	Clay					
				3.5	3.66	Combustible shale					
				3.66	3.88	Clay					
				3.88	4	Combustible shale					
				4	4.2	Clay					
				4.2	4.32	Combustible shale					
				4.32	5.06	Limestone					
				5.06	5.26	Coal	3.5	33.4	36.7	4.4	1.6
				5.26	5.36	Limestone					
				5.36	5.44	Coal					
				5.44	5.46	Clay					

Table 1. Borehole, adit, and trench data from exploration done by Tarayan (1942) and Drobotova and Saponjian (1996) on the Nor Arevik coal deposit—Continued

Point ID	Elev (m)	N coord	E coord	Top (m)	Btm (m)	Lithology	M (percent)	A (percent)	VM (percent)	TS (percent)	d (g/cm^3)
Shaft 6/41				5.46	5.55	Combustible shale					
Shaft 7/41	1501	355	325	0	0.36	Diluvium					
				0.36	0.47	Limestone					
				0.47	0.54	Coal					
				0.54	0.55	Limestone					
				0.55	0.59	Coal					
				0.59	0.7	Limestone					
				0.7	0.75	Coal					
				0.75	0.84	Limestone					
				0.84	0.85	Combustible shale					
				0.85	0.89	Limestone					
				0.89	0.9	Combustible shale					
				0.9	0.96	Limestone					
				0.96	0.99	Coal					
				0.99	1.28	Combustible shale					
				1.28	1.3	Clay					

Table 1. Borehole, adit, and trench data from exploration done by Tarayan (1942) and Drobotova and Saponjian (1996) on the Nor Arevik coal deposit—Continued

Point ID	Elev (m)	N coord	E coord	Top (m)	Btm (m)	Lithology	M (percent)	A (percent)	VM (percent)	TS (percent)	d (g/cm^3)
Shaft 7/41				1.3	1.4	Combustible shale					
Shaft 8/41	1518	412.5	347.5	0	0.65	Loam					
				0.65	1.9	Clay					
Shaft 9/41	1484	247.5	260	0	3.5	Loam					
				3.5	8.2	Sandy loam with gravel					
Trench 1/41	1475	95	112.5	0	0.9	Conglomerate					
				0.9	8.5	Sandstone					
				8.5	10	Conglomerate					
				10	10.75	Sandstone					
Trench 12/41	1507	240	412.5	0	0.25	Diluvium					
				0.25	0.3	Limestone					
				0.3	0.34	Coal					
				0.34	0.4	Limestone with fauna					
				0.4	0.5	Gypsum					
				0.5	0.67	Limestone					
				0.67	0.75	Gypsum					
				0.75	0.8	Marl					
				0.8	0.89	Coaly Clay					

Table 1. Borehole, adit, and trench data from exploration done by Tarayan (1942) and Drobotova and Saponjian (1996) on the Nor Arevik coal deposit—Continued

Point ID	Elev (m)	N coord	E coord	Top (m)	Btm (m)	Lithology	M (percent)	A (percent)	VM (percent)	TS (percent)	d (g/cm^3)
Trench 12/41				0.89	1.68	Combustible shale					
				1.68	1.76	Marl					
				1.76	1.81	Gypsum					
				1.81	1.84	Marl					
				1.84	1.99	Clay					
				1.99	2.12	Combustible shale					
				2.12	4.12	Clay					
Trench 13/41	1457	95	162.5	0	0.3	Diluvium					
				0.3	2.3	Sandstone					
				2.3	2.93	Clay					
				2.93	3.03	Coaly clay					
				3.03	3.13	Clay					
				3.13	3.23	Coal					
				3.23	3.25	Clay					
				3.25	3.27	Combustible shale					
				3.27	3.48	Limestone with fauna					
				3.48	3.49	Coal					

Table 1. Borehole, adit, and trench data from exploration done by Tarayan (1942) and Drobotova and Saponjian (1996) on the Nor Arevik coal deposit—Continued

Point ID	Elev (m)	N coord	E coord	Top (m)	Btm (m)	Lithology	M (percent)	A (percent)	VM (percent)	TS (percent)	d (g/cm^3)
Trench 13/41				3.49	3.52	Limestone					
				3.52	3.56	Coal					
				3.56	4.36	Clay					
				4.36	4.82	Coal					
				4.82	5.42	Limestone with fauna					
Trench 14/41	1486	185	347.5	0	0.35	Diluvium					
				0.35	0.75	Limestone					
				0.75	2.55	Combustible shale					
				2.55	2.65	Clay					
Trench 2/41	1475	95	132.5	0	0.2	Diluvium					
				0.2	7.95	Sandstone					
Trench 3/41	1470	80	147.5	0	0.25	Diluvium					
				0.25	5.95	Sandstone					
Trench 4/41	1470	57.5	192.5	0	0.08	Coal					
				0.08	0.18	Limestone					
				0.18	0.19	Coal					
				0.19	2.44	Sandstone					
				2.44	2.48	Combustible shale					

Table 1. Borehole, adit, and trench data from exploration done by Tarayan (1942) and Drobotova and Saponjian (1996) on the Nor Arevik coal deposit—Continued

Point ID	Elev (m)	N coord	E coord	Top (m)	Btm (m)	Lithology	M (percent)	A (percent)	VM (percent)	TS (percent)	d (g/cm^3)
Trench 4/41				2.48	4.29	Sandstone					
				4.29	4.7	Clay shale					
				4.7	5.17	Combustible shale					
				5.17	5.23	Coal					
				5.23	6.63	Sandstone					
Trench 5/41	1485	325	177.5	0	2.5	Diluvium					
Trench 6/41	1490	375	175	0	0.2	Diluvium					
				0.2	3.2	Sandstone					
Trench 7/41	1500	355	212.5	0	0.65	Clay					
				0.65	0.85	Coal					
				0.85	0.93	Clay					
				0.93	1.11	Coal					
				1.11	1.24	Combustible shale					
				1.24	2.17	Clay					
				2.17	2.63	Coal					
				2.63	2.71	Sooty coal					
				2.71	4.36	Clay					
Trench 8/41	1512	395	252.5	0	0.35	Clay					

Table 1. Borehole, adit, and trench data from exploration done by Tarayan (1942) and Drobotova and Saponjian (1996) on the Nor Arevik coal deposit—Continued

Point ID	Elev (m)	N coord	E coord	Top (m)	Btm (m)	Lithology	M (percent)	A (percent)	VM (percent)	TS (percent)	d (g/cm^3)
Trench 8/41				0.35	0.42	Combustible shale					
				0.42	0.45	Clay					
				0.45	0.5	Combustible shale					
				0.5	0.51	Clay					
				0.51	0.53	Combustible shale					
				0.53	0.54	Clay					
				0.54	0.59	Combustible shale					
				0.59	0.63	Clay					
Trench 9/41	1530	442.5	292.5	0	0.2	Diluvium					
				0.2	1.05	Clay					
				1.05	1.55	Coal					
				1.55	1.75	Clay					
				1.75	1.83	Coal					
				1.83	1.89	Clay					
				1.89	2.06	Coal					
				2.06	2.17	Combustible shale					

Table 1. Borehole, adit, and trench data from exploration done by Tarayan (1942) and Drobotova and Saponjian (1996) on the Nor Arevik coal deposit—Continued

Point ID	Elev (m)	N coord	E coord	Top (m)	Btm (m)	Lithology	M (percent)	A (percent)	VM (percent)	TS (percent)	d (g/cm^3)
Trench 9/41				2.17	4.89	Clay					
				4.89	4.97	Combustible shale					
				4.97	5.09	Clay					
				5.09	5.15	Combustible shale					
				5.15	5.25	Clay					
				5.25	5.28	Combustible shale					
				5.28	5.44	Clay					
				5.44	5.47	Combustible shale					
				5.47	5.61	Clay					
				5.61	5.65	Clay shale					
				5.65	5.75	Combustible shale					
				5.75	5.77	Clay					
				5.77	5.82	Combustible shale					
				5.82	5.93	Clay					
				5.93	5.99	Combustible shale					

Table 1. Borehole, adit, and trench data from exploration done by Tarayan (1942) and Drobotova and Saponjian (1996) on the Nor Arevik coal deposit—Continued

Point ID	Elev (m)	N coord	E coord	Top (m)	Btm (m)	Lithology	M (percent)	A (percent)	VM (percent)	TS (percent)	d (g/cm^3)
Trench 9/41				5.99	6.02	Clay					
				6.02	6.08	Combustible shale					
				6.08	6.14	Sandstone					
				6.14	6.34	Clay					
				6.34	6.4	Combustible shale					
				6.4	6.48	Combustible shale					
				6.48	7.15	Limestone					
				7.15	7.27	Coal					
				7.27	7.45	Limestone					
				7.45	7.55	Coal					
				7.55	8.7	Limestone					
Trench 9A/41	1524	412.5	290	0	0.15	Diluvium					
				0.15	0.35	Soot					
				0.35	0.36	Limestone					
				0.36	0.41	Coal					
				0.41	0.44	Limestone with fauna					
				0.44	0.52	Coal					

Table 1. Borehole, adit, and trench data from exploration done by Tarayan (1942) and Drobotova and Saponjian (1996) on the Nor Arevik coal deposit—Continued

Point ID	Elev (m)	N coord	E coord	Top (m)	Btm (m)	Lithology	M (percent)	A (percent)	VM (percent)	TS (percent)	d (g/cm^3)
Trench 9A/41				0.52	0.63	Limestone with fauna					
				0.63	0.65	Coal					
				0.65	0.8	Limestone with fauna					
				0.8	0.84	Coal					
				0.84	0.99	Combustible shale					
				0.99	1	Clay					
				1	1.06	Combustible shale					
				1.06	1.13	Clay					
				1.13	1.43	Combustible shale					

Table 2. Proximate analyses of samples from the Nor Arevik coal deposit

[SL, sample locality; SI, sample interval, thickness of sample not given unless a specific from-to is given in interval; SN, sample thickness; AM, analytical moisture; Ash-1, ash, air dried basis from Tarayan (1942), dry basis from Pierce and others (1994), and as determined basis from Drobotova and Saponjian (1996); VM-1, volatile matter, air dried basis from Tarayan (1942), dry basis from Pierce and others (1994), and as determined basis from Drobotova and Saponjian (1996); TS, total sulfur content, basis not reported from Tarayan (1942) and dry basis for Pierce and others (1994); Ash-2, ash yield after washing the coal samples; VM-2, volatile matter, after washing the coal samples; SG, specific gravity; Gg-o, Getyglykh outcrop sample; Kh-o, Khavot outcrop sample; Kh-tr #, Khavot trench sample; Kh-sh #, Khavot shaft sample; NR, not reported; strip, small strip mine located in figure 2; Str, stripping; Bh, borehole; brn gy, brown gray; blk, black; gry blk, gray black; dtc, difficult to clean; [1] moisture and volatile matter of Tarayan (1942) are unreported basis]

SL	SI (m)	SN	Lithology	AM (percent)	Ash-1 (percent)	VM-1 (percent)	TS (percent)	Ash-2 (percent)	VM-2 (percent)	SG
Tarayan (1942)										
Gg-o	0.3	2	coal	5.47	13	34.9	5.58	NR	NR	1.4
Kh-o	0.4	8	coal	8.68	6.5	35.64	3.56	NR	NR	1.3
Kh-tr 11	0.7	24	coal	4.91	20.11	36.08	5.79	NR	NR	1.46
Kh-sh 5	4.5	21	coal	5.67	49.45	27.22	8.18	NR	NR	1.84
Kh-sh 5	5.4	22	coal	4.03	52	25.5	6.14	NR	NR	1.78
Kh-sh 6	5.2	25	coal	3.45	33.36	36.73	4.37	NR	NR	1.59
Kh-sh 10	4.8	26	coal	5.7	20.24	38.42	5.16	NR	NR	1.48
Pierce and others (1994)										
Strip	1	Meg-1	carbona-ceous shale and coal	18.44	47.58	29.81	5.37	NR	NR	NR
Strip	0.52	Meg-2	carbona-ceous shale	14.08	72.68	18.35	7.27	NR	NR	NR

Table 2. Proximate analyses of samples from the Nor Arevik coal deposit—Continued

Drobotova and Saponjian (1996)										
SL	SI (m)	SN	Lithology	AM (percent)	Ash-1 (percent)	VM-1 (percent)	TS (percent)	Ash-2 (percent)	VM-2 (percent)	SG
Strip	0.54	Meg-3	carbona-ceous shale	13.39	67.43	24.36	5.84	NR	NR	NR
Str-1	3	NR	brn gy siltstone	5.7	77.3	14.1	NR	dtc	dtc	2.36
Str-1	3.5	0.2	siltstone	8.9	73.6	13.6	NR	dtc	dtc	2.22
Str-1	7.5	NR	brn gy siltstone	5.1	76	12.1	NR	dtc	dtc	2.34
Str-1	7.5	NR	siltstone	5.2	60.6	19.1	NR	18.7	41.3	2.06
Str-1	7.5	0.1	tuff siltstone	3.5	68.6	19.6	NR	dtc	dtc	2.36
Str-1	10.8	0.2	siltstone w/ bitumen	14.2	16.5	29.8	NR	14.6	32.8	1.53
Str-1	13.5	0.2	siltstone	4.7	52	25.9	NR	dtc	dtc	1.86
Str-1	16	NR	gry blk siltstone	5.4	74.8	16.1	NR	dtc	dtc	2.33
Str-1	16	0.6	siltstone w/ bitumen	8	73	13	NR	dtc	dtc	2.19
Str-1	18.6	NR	gry blk siltstone	5	62.7	22.7	NR	33.6	45.1	2
Str-1	18.6	0.7	tuff siltstone	5.6	70	13.8	NR	dtc	dtc	2.33
Str-1	23	1	siltstone w/ gypsum	6.4	62.6	17.2	NR	dtc	dtc	2.04
Str-1	23.5	1	siltstone w/ sulfur	6.7	57.5	18.5	NR	dtc	dtc	1.94

Table 2. Proximate analyses of samples from the Nor Arevik coal deposit—Continued

Drobotova and Saponjian (1996)—Continued										
SL	SI (m)	SN	Lithology	AM (percent)	Ash-1 (percent)	VM-1 (percent)	TS (percent)	Ash-2 (percent)	VM-2 (percent)	SG
Str-1	24	0.5	siltstone	3.6	64.6	23.1	NR	dtc	dtc	2.01
Str-1	24	0.2	siltstone w/ bitumen	3.9	53.6	23	NR	dtc	dtc	1.93
Str-1	24	0.2	siltstone and marl	8.3	17	31.9	NR	12.2	34.4	1.51
Str-1	24	0.2	siltstone and marl	7.2	29.1	31.4	NR	17.8	38.2	1.63
Str-1	25	0.1	siltstone w/ bitumen	4.6	41.7	19.2	NR	dtc	dtc	2.07
Str-1	25	0.2	siltstone and marl	4.6	44	25	NR	dtc	dtc	1.79
Str-1	28	1	siltstone	4	45.5	29.3	NR	dtc	dtc	1.72
Str-1	28	0.1	siltstone and marl	6.1	34.3	26.5	NR	14.7	34.1	1.79
Str-1	28	0.1	siltstone	4.7	69.7	17.6	NR	dtc	dtc	2.09
Str-1	28	0.1	tuff siltstone w/ bitumen	10.5	23.3	31.2	NR	19.4	35.6	1.54
Str-1	29	0.2	“fat” siltstone	4.1	57.6	18.5	NR	dtc	dtc	1.79
Str-2	7	0.1	siltstone w/ bitumen	4.8	27.2	31.9	NR	19.1	37.8	1.49
Str-2	9	0.1	siltstone w/ bitumen	6.8	13.6	31.9	NR	6.4	33.6	1.48

Table 2. Proximate analyses of samples from the Nor Arevik coal deposit—Continued

Drobotova and Saponjian (1996)—Continued										
SL	**SI (m)**	**SN**	**Lithology**	**AM (percent)**	**Ash-1 (percent)**	**VM-1 (percent)**	**TS (percent)**	**Ash-2 (percent)**	**VM-2 (percent)**	**SG**
Str-2	9	NR	blk siltstone	4.8	62.6	20.1	NR	dtc	dtc	2.2
Str-2	9	NR	siltstone w/ iron	6.3	57.6	21	NR	dtc	dtc	2.59
Str-2	9	NR	siltstone w/ iron	9.9	31	30.4	NR	19.7	42	1.72
Str-2	11	0.1	siltstone w/ gypsum, sulfur, and bitumen	6.7	30.9	31.8	NR	20.8	36.8	1.62
Str-2	12.5	0.1	siltstone w/ bitumen	5.8	22	32.4	NR	21.2	36.5	1.59
Str-3	12	NR	gry blk siltstone	4.4	76.9	14.8	NR	dtc	dtc	2.41
Str-3	14	NR	blk siltstone	4.8	61.3	21.2	NR	19.8	39.7	2.12
Str-3	14	NR	siltstone w/ bitumen	4.9	32.2	31.6	NR	17.9	40.1	1.71
Str-3	14	NR	siltstone w/ bitumen and sulfur	7	43	29.9	NR	17.3	39.1	1.81
Str-3	14	NR	siltstone w/ sulfur	6.1	23.3	31.4	NR	19.1	36.3	1.58
Str-4	7.5	NR	siltstone	8.3	56.6	25.6	NR	20.2	55.7	1.99
Str-4	12	NR	siltstone w/ bitumen	11.3	23.6	32	NR	18.2	40.3	1.66

Table 2. Proximate analyses of samples from the Nor Arevik coal deposit—Continued

Drobotova and Saponjian (1996)—Continued										
SL	**SI (m)**	**SN**	**Lithology**	**AM (percent)**	**Ash-1 (percent)**	**VM-1 (percent)**	**TS (percent)**	**Ash-2 (percent)**	**VM-2 (percent)**	**SG**
Str-4	17	0.2	siltstone w/ bitumen	6.3	34.3	26.5	NR	dtc	dtc	2.12
Str-4	44	0.1	siltstone w/ bitumen	14.7	24.8	31.9	NR	23.1	29.9	1.63
Str-4	48	NR	siltstone	4	56.1	26.3	NR	dtc	dtc	1.89
Str-4	48	0.1	tuff siltstone w/ bitumen	9.4	18	32.4	NR	13.4	35.4	1.55
Str-4	50.6	0.5	tuff siltstone	8.9	72.3	14	NR	dtc	dtc	2.22
Str-4	52	NR	gry blk siltstone	5	67.6	16	NR	dtc	dtc	2.17
Str-8	5.8	0.5	siltstone w/ bitumen and sulfur	9	18	31.8	NR	14.6	40.2	1.5
Str-8	8.2	0.5	siltstone	9.6	42.4	24.4	NR	dtc	dtc	1.8
Str-8	12	0.5	tuff siltstone	12.2	25.2	29.2	NR	18.8	31.9	1.62
Str-8	16	0.5	siltstone w/ bitumen and sulfur	7.6	12.3	34	NR	12.1	36.8	1.49
Str-11	12.5	0.5	siltstone	6.2	71.6	17.2	NR	dtc	dtc	2.28
Bh 2		0.0-0.8	siltstone and bitumen	1	46.9	27.3	NR	NR	NR	NR
		0.8-4.0	siltstone w/ bitumen	3.2	56.3	22.2	NR	NR	NR	NR

Table 2. Proximate analyses of samples from the Nor Arevik coal deposit—Continued

Drobotova and Saponjian (1996)—Continued										
SL	**SI (m)**	**SN**	**Lithology**	**AM (percent)**	**Ash-1 (percent)**	**VM-1 (percent)**	**TS (percent)**	**Ash-2 (percent)**	**VM-2 (percent)**	**SG**
Bh 2		4.0-8.0	"soaked" siltstone	1	53.8	26.7	NR	NR	NR	NR
		8.0-10.0	"soaked" siltstone	1.6	63.4	27	NR	NR	NR	NR
		10.0-12.8	"soaked" siltstone	0.3	77.6	15.9	NR	NR	NR	NR
Bh 3		0.1-0.6	siltstone	1.2	77.8	16.9	NR	NR	NR	NR
		0.6-1.2	siltstone	3.5	78.4	13.5	NR	NR	NR	NR
		1.2-3.5	siltstone	0.2	82.6	14.3	NR	NR	NR	NR
		3.5-5.5	siltstone	0.6	85	13.1	NR	NR	NR	NR
Bh 4		8.8-12.0	siltstone	0.5	87.5	11.4	NR	NR	NR	NR
		12.0-13.7	siltstone	2	90.6	7.1	NR	NR	NR	NR
		13.7-14.7	siltstone	2.2	88.1	8.3	NR	NR	NR	NR
		14.7-17.0	siltstone	1.5	87.4	9.3	NR	NR	NR	NR
		17.0-19.0	siltstone	0.6	84.2	12.5	NR	NR	NR	NR
		19.0-22.0	siltstone interbedded w/ marl	1.2	75.9	17.6	NR	NR	NR	NR
		22.0-24.0	siltstone	1.2	75.9	17.6	NR	NR	NR	NR
		24.0-27.0	siltstone	2.1	76.3	16.8	NR	NR	NR	NR
		27.0-30.0	siltstone	1.2	79.7	14.5	NR	NR	NR	NR

Table 2. Proximate analyses of samples from the Nor Arevik coal deposit—Continued

Drobotova and Saponjian (1996)—Continued										
SL	**SI (m)**	**SN**	**Lithology**	**AM (percent)**	**Ash-1 (percent)**	**VM-1 (percent)**	**TS (percent)**	**Ash-2 (percent)**	**VM-2 (percent)**	**SG**
Bh 4		30.0-32.0	siltstone	2	78.7	15.7	NR	NR	NR	NR
		32.0-34.0	siltstone w/ tuff sandstone	1.9	78.8	16.5	NR	NR	NR	NR
		34.0-36.0	siltstone	2.3	78.2	15.5	NR	NR	NR	NR
		36.0-37.0	siltstone	2.6	80.6	12.7	NR	NR	NR	NR
		37.0-38.0	tuff siltstone	2.3	74.7	17.2	NR	NR	NR	NR
		38.0-40.0	siltstone interbedded w/ marl	0.9	80.3	16.2	NR	NR	NR	NR
		40.0-42.5	siltstone	3.1	81.1	13.8	NR	NR	NR	NR
		42.5-45.0	tuff conglomer-ate (and?) siltstone	2.2	84.6	11.1	NR	NR	NR	NR
		45.0-46.0	alternating siltstone and tuff sandstone	2.1	81.8	13.3	NR	NR	NR	NR
		46.0-47.7	siltstone w/ marl and bitumen	2.8	57.3	21.5	NR	NR	NR	NR

Table 2. Proximate analyses of samples from the Nor Arevik coal deposit—Continued

Drobotova and Saponjian (1996)—Continued										
SL	**SI (m)**	**SN**	**Lithology**	**AM (percent)**	**Ash-1 (percent)**	**VM-1 (percent)**	**TS (percent)**	**Ash-2 (percent)**	**VM-2 (percent)**	**SG**
Bh 4		47.7-50.0	siltstone (and?) alternating tuffites and tuff conglomer-ates	2.1	87.8	7.7	NR	NR	NR	NR
Bh 5		4.0-5.0	siltstone	3.1	75.8	15.7	NR	NR	NR	NR
		5.0-8.0	siltstone	1.2	72.1	20.8	NR	NR	NR	NR
		8.0-10.0	alternating siltstone, argillite, and marl	1.6	80	15.1	NR	NR	NR	NR
		10.0-12.0	siltstone	3.1	75.5	17.8	NR	NR	NR	NR
		12.0-14.0	siltstone	1	78.3	16.8	NR	NR	NR	NR
		14.0-17.0	siltstone	2.9	77.9	14.6	NR	NR	NR	NR
		17.0-20.0	siltstone	1.1	81.7	15.7	NR	NR	NR	NR
		20.0-21.0	alternating siltstone, argillite, and marl	2.6	78.2	15.4	NR	NR	NR	NR
		27.4-30.0	siltstone	2.3	81.3	12.8	NR	NR	NR	NR

Table 2. Proximate analyses of samples from the Nor Arevik coal deposit—Continued

Drobotova and Saponjian (1996)—Continued										
SL	**SI (m)**	**SN**	**Lithology**	**AM (percent)**	**Ash-1 (percent)**	**VM-1 (percent)**	**TS (percent)**	**Ash-2 (percent)**	**VM-2 (percent)**	**SG**
Bh 5		30.0-33.0	alternating siltstone, argillite, and marl	2.1	81.6	11.8	NR	NR	NR	NR
		33.0-35.0	alternating siltstone, argillite, and marl	1.4	81.6	13	NR	NR	NR	NR
		35.0-36.0	alternating siltstone, argillite, and marl	1.8	82.4	13.4	NR	NR	NR	NR
Bh 6		6.0-8.0	alternating siltstone, argillite, and marl	2.5	75.3	18.1	NR	NR	NR	NR
		8.0-10.0	siltstone	0.8	72.6	20.8	NR	NR	NR	NR
		10.0-13.0	alternating siltstone, argillite, and marl	1.6	74.7	17.1	NR	NR	NR	NR
		13.0-15.0	alternating siltstone, argillite, and marl	2.6	78.1	14.1	NR	NR	NR	NR

Table 2. Proximate analyses of samples from the Nor Arevik coal deposit—Continued

Drobotova and Saponjian (1996)—Continued										
SL	**SI (m)**	**SN**	**Lithology**	**AM (percent)**	**Ash-1 (percent)**	**VM-1 (percent)**	**TS (percent)**	**Ash-2 (percent)**	**VM-2 (percent)**	**SG**
Bh 6		15.0-16.5	alternating siltstone, argillite, and marl	2.7	80.8	14.1	NR	NR	NR	NR
		16.5-18.0	alternating siltstone, argillite, and marl	1.6	78.2	16.3	NR	NR	NR	NR
		18.0-19.5	alternating siltstone, argillite, and marl	3	79.1	12.4	NR	NR	NR	NR
		19.5-21.0	alternating siltstone, argillite, and marl	2.4	78.1	17.3	NR	NR	NR	NR
		21.0-24.0	alternating siltstone, argillite, and marl	2	80.3	14.5	NR	NR	NR	NR
		24.0-25.0	alternating siltstone, argillite, and marl	4.1	78.1	15	NR	NR	NR	NR

Table 2. Proximate analyses of samples from the Nor Arevik coal deposit—Continued

Drobotova and Saponjian (1996)—Continued										
SL	**SI (m)**	**SN**	**Lithology**	**AM (percent)**	**Ash-1 (percent)**	**VM-1 (percent)**	**TS (percent)**	**Ash-2 (percent)**	**VM-2 (percent)**	**SG**
		28.0-30.0	alternating siltstone, marl, argillite, and tuffite	3.3	79.4	15.1	NR	NR	NR	NR
		30.0-33.0	alternating siltstone, marl, argillite, and tuffite	3.6	82.8	11.5	NR	NR	NR	NR
		33.0-34.0	alternating siltstone, marl, argillite, and tuffite	3.6	83.3	9.8	NR	NR	NR	NR
		34.0-35.0	alternating siltstone, marl, argillite, and tuffite	0.7	81.6	13.1	NR	NR	NR	NR

Table 3. Chemical analyses of combustible shales from Drobotova and Saponjian (1996)

[There are no localities nor thicknesses given in the reference for any of the samples. SN, sample number in original report; AM, analytical moisture; Ash yield, dry basis; VM, volatile matter, as determined basis; Sulfur basis not given but probably as determined]

SN	AM (percent)	Ash (percent)	VM (percent)	Density (g/cm^3)	Sulfur (percent)
159	1.8	90.7	6.7	2.7	0.82
164	4.2	84.1	9.3	2.66	3.25
165	2.9	89.9	6.8	2.67	0.9
166	3.7	83.2	9.9	2.7	2.78
169	2.8	77.3	14.9	2.59	3.33
172	3.3	82	11.9	2.65	3.53
174	2.6	75.8	18.4	2.45	4.1
175	1.5	77.5	11.6	2.69	4.78
176	3.5	67.5	15.4	2.56	2.58
177	3.3	81	14.6	2.67	4.06
178	4.6	81.9	10.8	2.56	3.54
180	3.1	80.2	14	2.56	2.75
181	3.6	71.2	15	2.34	3.66
184	1.2	88.5	9.8	2.69	0.65
185	0.8	90.3	6.5	2.66	0.78
(1)	0.5	61	16.9	NR	0.76

Table 4. Calorific values of selected samples of the Nor Arevik coal deposit

[SL = sample locality; M = moisture; A = ash yield, on an air dried basis for Tarayan (1942), unreported basis for Drobotova and Saponjian (1996), and dry basis for Pierce and others (1994); CV-1 = calorific value, as determined basis; CV-2 = calorific value, dry basis (air dried basis for Tarayan (1942); CV-3 = calorific value, dry ash-free basis; Gg-o = Getyglykh outcrop sample; Kh-o = Khavot outcrop sample; Kh-tr # = Khavot trench sample; Kh-sh # = Khavot shaft sample; Str = stripping; NR = not reported]

SL	Lithology	M (percent)	A (percent)	CV-1 (cal/g)	CV-2 (cal/g)	CV-3 (cal/g)
Tarayan (1942)						
Gg-o	coal	5.47	13	NR	6103	NR
Kh-o	coal	NR	NR	NR	5235	NR
Kh-o	coal	8.68	6.5	NR	5873	NR
Kh-o	coal	NR	NR	NR	2477	NR
Kh-tr 11	coal, at 0.7 m	4.91	20.11	NR	6359	NR
Kh-tr 13	coal, at 0.6 m	NR	NR	NR	5167	NR
Kh-sh 5	coal, at 4.5 m	5.67	49.95	NR	3360	NR
Kh-sh 5	coal, at 5.4 m	4.03	52	NR	3405	NR
Kh-sh 6	coal, at 5.2 m	3.45	33.36	NR	6827	NR
Kh-sh 10	coal, at 4.8 m	5.7	20.24	NR	6234	NR
Kh-sh 11	coal, at 0.8 m	NR	NR	NR	5283	NR
Kh-sh 11	dull coal, at 1.0 m	NR	NR	NR	2889	NR
Drobotova and Saponjian (1996)						
Str-1	bitumen with paraffin (on marl)	9	18.5	5042	5498	6750
Str-2	bitumen with gypsum and sulfur	8.3	14.6	5636	6047	7080

Table 4. Calorific values of selected samples of the Nor Arevik coal deposit—Continued

Drobotova and Saponjian (1996)						
SL	**Lithology**	**M (percent)**	**A (percent)**	**CV-1 (cal/g)**	**CV-2 (cal/g)**	**CV-3 (cal/g)**
Str-2	bitumen	8.1	23.3	4581	5339	6610
Str-2	bitumen	6.2	28.6	4635	4913	6420
Str-4	bitumen on tuff	11.1	19.9	4730	5221	6515
Str-4	bitumen	15.37	19.2	4581	5339	6610
Str-4	bitumen	16.2	29	3645	4775	6025
Str-8	siltstone with bitumen and sulfur	11.2	19.8	4894	5378	6705
Str-8	tuffite with bitumen and sulfur	9.1	13.3	5695	6163	7210
Str-8	tuffite with bitumen	15.3	28.7	3850	4385	6150
Pierce and others (1994)						
Meg-1	carbona-ceous shale and coal	18.44	47.59	NR	3248	6170
Meg-2	carbona-ceous shale	14.08	72.68	NR	1501	5493
Meg-3	carbona-ceous shale	13.39	67.43	NR	2335	7168

Table 5. Elemental analyses of Nor Arevik samples from Drobotova and Saponjian (1996)

[SL, sample locality; SD, sample description; M, moisture; S, sulfur; P, phosphorous; Cl, chlorine; As, arsenic; Str, stripping]

SL	SD	M (percent)	S (percent)	P (percent)	Cl (percent)	As (percent)
Str-1	siltstone with bitumen	3.7	5.24	0.004	0.28	0.0002
Str-1	siltstone with bitumen	3.4	3.78	0.008	0.25	0.0002
Str-1	siltstone with bitumen	3.34	4.36	0.02	0.21	0.0002
Str-1	siltstone with bitumen	4.44	2.26	0.028	0.25	0.0002
Str-1	siltstone with bitumen	2.9	4.62	0.012	0.28	0.0004
Str-2	siltstone with bitumen	2.28	4.51	0.022	0.25	0.0002
Str-2	siltstone with bitumen	3.32	7.62	0.004	0.21	0.0006
Str-2	siltstone with bitumen and iron	4.13	4.65	0.004	0.25	0.0002
Str-2	siltstone with bitumen	6.57	3.88	0.01	0.25	0.0002
Str-2	small pieces of ash[1]	0.58	1.7	0.004	0.21	0.0002
Str-2	large pieces of ash[1]	0.47	1.55	0.004	0.18	0.0002
Str-3	siltstone with bitumen	2.6	4.21	0.032	0.25	0.0002
Str-3	siltstone with bitumen	2.92	7.9	0.004	0.21	0.001
Str-3	siltstone with bitumen	4.41	2.85	0.016	0.25	0.0006
Str-3	siltstone with bitumen and sulfur	3.53	5.76	0.028	0.15	0.0002
Str-4	siltstone with bitumen	3.23	4.66	0.004	3.23	0.0002
Str-4	volcaniclastics full of bitumen	2.33	4.74	0.004	0.25	0.0002
Str-4	volcaniclastics soaked in bitumen	5.37	4.42	0.004	0.25	0.0002
Str-4	bitumen	7.92	3.47	0.04	0.18	0.0002

[1] We think (but are not sure) that these samples were taken from stripping 2 and burned in a stove; the pieces that remained were analyzed. The entries are as they appear in the original table.

Table 6. Results of dry distillation analyses of combustible shale samples from Tarayan (1942)

[SN, sample number from the original report; SL, sample locality; SI, sample interval; Tar, tar yield; TW, Tar water yield; G&L, gas and losses; CV, calorific value, dry basis; NR, not reported]

SN	SL	SI (m)	Tar (percent)	TW (percent)	G&L (percent)	CV (cal/g)
NR	Getyglukh outcrop	0.4	4.5	11.5	NR	1653
4	Khavot outcrop	0.3	4	10.6	3	1270
5	Khavot outcrop	0.3	4.8	12	1.2	1235
6	Khavot outcrop	0.3	8.8	12	2.4	2254
9	Khavot outcrop	0.4	6	10.4	3.2	1556[1]
10	Khavot outcrop	0.3	4	12	0.8	1272
11	Khavot outcrop	0.4	6.8	10	3.2	1873[1]
12	Khavot outcrop	0.4	6.4	10.6	3.2	1529
13	Khavot outcrop	0.3	6	8	4	1547
14	Khavot outcrop	0.3	2.4	18	4.4	1065
16	Khavot shaft no. 3	5.5-6.0	4.8	11.2	1.2	1587

[1]These values differ from the ones given in the table on page 7. However, both sets of numbers were transcribed as they appeared in Taryan's (1942) work. Because we have no way of knowing which set is correct, we have chosen to reproduce the numbers exactly as Taryan gave them.

Table 7. Results of oil and gas analyses from Drobotova and Saponjian (1996)

[Location, lithology, or other similar information for the samples is not given by these authors. SN, sample number, from original report; M_d,moisture on an air-dried samples; M_w, moisture on undried samples; IR, insoluble residue; CL, calcination loss; Ash, ash yield, reporting basis not given; OC, organic carbon; HA, humic acid; Cl E, by chlorine extract; A B, by alcohol benzol extract; Type, type of bitumen present; np, not present]

SN	M_d (percent)	M_w (percent)	IR (percent)	CL (percent)	Ash (percent)	CO_2 (percent)	S (percent)	OC (percent)	HA (percent)	Cl E (percent)	A B (percent)	Type
1	5.66	6	86.18	51.04	48.96	0.1572	8.2566	4.91	0.1312	1.25	0.31	tar bitumen A
2	3.73	3.88	81.95	42.27	57.73	2.2185	6.4886	4.52	0.1131	0.31	0.31	tar bitumen A & tar-asphaltene bitumen A
4	5.14	4.71	88.75	49.02	50.98	2.0071	5.0755	2.4	0.114	0.31	0.31	tar bitumen A
5	7.04	7.58	85.36	44.54	55.46	1.2741	6.08	3.32	0.1012	0.31	0.31	tar-asphaltene bitumen A
6	4.9	5.16	80.09	60.73	39.17	np	6.9925	3.8	0.1406	0.31	0.31	tar bitumen A
7	4.56	4.77	89.39	60.22	39.78	0.1695	5.9883	6.05	0.1244	1.25	0.31	tar bitumen A
8	4.71	4.95	87.65	40.17	59.83	0.1578	6.2362	3.19	0.1324	0.235	0.31	tar-asphaltene bitumen A
9	5.14	5.42	83.45	68.09	31.91	0.5066	5.394	3.05	0.1018	0.235	0.31	tar bitumen A
12	2.6	2.67	96.47	51.86	48.14	0.2669	5.0593	1.7	0.0889	0.235	0.31	tar bitumen A

Table 8. Ultimate analyses of Nor Arevik coal samples from Pierce and others (1994)

[All analyses are reported on an as-received basis. SN, sample number; C, carbon; H, hydrogen; N, nitrogen; S, sulfur; O, oxygen]

SN	C (percent)	H (percent)	N (percent)	S (percent)	O (percent)
Meg - 1	27.72	4.25	0.72	4.38	24.12
Meg-2	11.95	2.96	0.34	6.25	16.06
Meg-3	17.6	3.61	0.42	5.06	14.91

Table 9. Coal resource calculations of the Nor Arevik coal deposit by Tarayan (1942)

[For a discussion of the reporting categories, see the text. Area = area calculated for resource; Resource = tonnage resource]

Category	Area (m^2)	Average bed thickness (m)	Volume (m^3)	Density (g/cm^3)	Resource (m tonnes)
C_1	5,625	0.72	4,050	1.4	5,670
C_1	26,500	0.37	9,805	1.4	13,787
C_2	2,500	0.88	2,020	1.4	2,828
				Total coal resources	22,285

Table 10. Combustible shale resources of the Nor Arevik coal deposit by Tarayan (1942)

[Differences between the blocks are different coal beds used in the calculation. Block No., block number that Tarayan (1942) used in his resource calculation; Area, area of each block; Avg Thick, average thickness of the beds used in each block; Volume, volume of the resource in each block; d, density used in resource calculation; Resource, tonnage resource]

Block No.	Category	Area (m^2)	Avg Thick (m)	Volume (m^3)	d (g/cm^3)	Resource (m tonnes)
1	C_1	18,875	0.78	14,722	1.9	27,972
2	C_1	18,875	1.84	34,730	1.8	62,514
3	C_1	24,562	0.63	15,474	1.9	29,401
4	C_1	24,562	2.45	60,177	1.8	108,318
Total C_1 resources, 228,205 metric tonnes						
5	C_2	20,230	2.33	27,327	1.9	89,922
6	C_2	42,025	0.72	30,240	1.9	57,456
7	C_2	42,025	1.63	68,460	1.8	123,364
Total C_2 Resources						270,642
Total of the Khavot area, 498,847 metric tonnes						

Table 11. Calculation of combustible shale resources by Drobotova and Saponjian (1996)

[Block, the authors' area of individual resource calculations; Area, area of block calculated; Thickness, cumulative thickness of the combustible shales in each block; Volume, volume of the resource in each block; d, density used in resource calculation; Resource, tonnage resource]

Block	Area (m^2)	Thickness (m)	Volume (m^3)	d (g/cm^3)	Resource (m tonnes)
1C1	6,954	19.3	134,212	2.6	348,951
2C1	11,212	20.2	226,842	2.6	588,854
3C1	10,575	31.9	337,342	2.6	877,090
4C2	2,419	13.1	31,689	2.6	82,391
5C2	5,812	21.7	126,120	2.6	327,912
				Total by category C_1	1,814,895
				Total by category C_2	410,303
				Total of $C_1 + C_2$	2,225,198