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PRACTICAL APPLICATION OF THE UNITED NATIONS FRAMEWORK CLASSIFICATION FOR RESERVES/RESOURCES

APPLICATION TO KEY LAKE DEPOSITS

(Submitted by the Government of Canada) */ **/

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INTRODUCTION

During the period from 1975 to 1997 several resource/reserve estimations were done for the Key Lake deposits including some carried out by various mining companies, mine site personnel and mining consultants. The relevant resource/reserve estimations are classified using the codes proposed by the United Nations International Framework Classification for Reserves/Resources (Table 1).

THE DEPOSIT

The Key Lake area is located in northern Saskatchewan, Canada. Two uranium deposits, the Gärtner and the Deilmann deposit, occur in the Key Lake area. They are unconformity related uranium deposits situated at the contact of the Middle Proterozoic Athabasca Group (sandstone/conglomerate) and the underlying Lower Proterozoic Wollaston Group meta-sediments (gneisses). The Gärtner deposit is 850 m long, with a width ranging from 10 m to 40 m and the Deilmann deposit is 950 m long with a width ranging from 20 m to 120 m. The thickness of both deposits ranges from 5 m to 50 m. The plan projection of the deposits and the typical cross sections are shown in figure 1. The Gärtner deposit was mined from 1983 to 1987 and the Deilmann deposit from 1986 to 1997.

PROSPECTING AND EXPLORATION

In 1969 Uranerz Exploration and Mining Limited and its joint venture partners initiated the reconnaissance activities in northern Saskatchewan (Gatzweiler 1981). In 1971 numerous radioactive boulders containing high grade uranium mineralization were discovered 5 km southwest of Key Lake. Detailed prospecting, geological mapping, geochemical sampling and geophysical surveys were carried out in the following years. The objective of the reconnaissance and prospecting activities was to discover a deposit similar to the Rabbit Lake uranium deposit, which was discovered approximately 120 km northeast of Key Lake in 1968. The published reserve of the Rabbit Lake deposit was 18,000 tonnes U_3O_8 with an average grade of 0.45 % U_3O_8.

In July 1975, after the drilling of 25 holes in the Key Lake area, the first drill core containing several meters of high grade uranium mineralization was recovered (Kirchner 1993). Favorable geologic structures, alteration features and anomalous uranium were encountered in other drill holes. Immediately after the discovery, detailed drilling along strike of the mineralized intersection, using 25 m line-spacings and 10 m hole intervals, was carried out. At the end of the 1975 field season a 200 m mineralized zone, named the Gärtner deposit, was outlined. The initial resource estimation of this zone suggested a minimum of 10,000 tonnes U_3O_8 grading 2 % to 3 % U_3O_8. This indicated resource was manually estimated by Uranerz using the polygonal method. The relevant geologic controls of the deposit such as the structural setting and the alteration features were established. Based on geological and geophysical interpretation, additional potential along strike was inferred.

In the winter of 1976, with strong confidence in the potential of the deposit, large scale detailed exploration drilling was carried out, utilizing up to twelve drill rigs. Line-spacing of 25 m and hole intervals of 10 m were used to delineate the deposit. The in-fill holes with 12.5 m line spacing were drilled in the very high grade zones. In addition, exploratory holes were drilled along strike of the Gärtner deposit which lead to the discovery of the Deilmann deposit in the summer of 1976. The Deilmann deposit is located 1,200 m northeast of the Gärtner deposit. Detailed exploration drilling was carried out until 1979. During the period of 1975 to 1979, a total of 2,415 drill holes with a cumulative length of 266,800 m (average hole length of 110 m) were completed in the Key Lake area.

RESERVES ESTIMATION

In 1977-1978 the first reserves estimation of the Gärtner deposit was done by EBC GmbH of Aachen, Germany and Uranerzbergbau GmbH (UEB), Bonn, Germany. The classical polygonal block model method with a 25 x 10 x 3.048 meter block size was used. The block size and orientation follows the 25 x 10 meter drill grid pattern. In the UN International Framework Classification the estimation can be classified as a pre-feasibility estimation. Metallurgical testing, geotechnical and hydrological studies were also conducted during this period. The pre-feasibility study report was completed in October 1979.

In 1979-1980 the reserves estimation for the feasibility study was carried out by IREM-MERI of Montreal, Canada. The ore grades obtained from the chemical assays and the down-hole radiometric logging results were used for the estimation. The three dimensional linear kriging method with a block size of 25 x 20 x 4 meters was used. The deposits were divided into several zones. Various search ellipsoids of 30 m - 40 m for the long axis, 15 m - 40 m for the intermediate axis and 4 m - 13 m along the vertical direction were used. The estimated 25 x 20 x 4 meter blocks were subdivided into 2 x 2 x 2 meter units, which were used for ore and waste separation at various cut-off grades.

MINE PRODUCTION

The actual ores mined from both the Gärtner and Deilmann deposits are compared with the various reserves estimations as shown on table 2. A total of 22,971 tonnes of U_3O_8 (1,230,578 tonnes of ore grading 2.18 % U_3O_8) were mined from the Gärtner deposit. A total of 61,234 tonnes of U_3O_8 (2,486,609 tonnes of ore grading 2.46 % U_3O_8) were mined from the Deilmann deposit, which includes the mill production of 47,076 tonnes U_3O_8 (1,684,720 tonnes of ore grading 2.74 % U_3O_8) to the end of April plus the estimated 14,159 tonnes of U_3O_8 (801,889 tonnes of ore grading 1.77 % U_3O_8) from the ore stockpiles. The stockpiles are presently being milled.

The U_3O_8 content estimated from the Gärtner deposit by IREM-MERI in 1979 are between 18 % to 30 % higher than actual mine production. In 1985 the reserves of the Gärtner deposit were re-estimated by Geostats System International (formerly IREM-MERI) using the additional 12.5 m in-fill drillholes. The estimation difference with actual mine production was reduced to less than 1 %. The uranium content estimated from the Deilmann deposit are around 10 % lower than actual mine production. Apart from estimations done by mine-site personnel, no additional reserves estimations by outside consultants were carried out.

The various reserves estimations demonstrated that the uranium content of the Gärtner and Deilmann deposits can be reasonably estimated using detailed exploration holes, however, the ore dilutions are more difficult to estimate. Ore tonnage estimations from both deposits are up to 52 % lower and ore grades up to 80 % higher than actual mine production. However, since the mining cut-off grade (0.2 % U_3O_8) is much smaller than the actual ore grades (2.18 % - 2.46 % U_3O_8), the higher dilution factors did not greatly affect the economic viability of the mine.

After mining of the Deilmann deposit was completed in 1997, the blast hole data from the Deilmann pit was compiled and the ore reserves re-estimated (Mistry 1997). The blast holes were drilled in grid patterns of 6.5 m to 7 m center. The reserves estimation was done for each bench (4 m to 8 m benches) using the 2 dimensional inverse distance squared method. The block size of 7.5 x 7.5 meters was used and a very short isotropic search radius of 3.75 m was applied. The estimated reserves, including the ore tonnage, are quite close to the actual mine production. The difference between ore tonnage, uranium content and ore grade estimations and actual mine production is close to the 10 % range.

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Compilation of Key Lake's Ore Reserve Models During Exploration, Development and Mining Including Reconciliation with Actual Mine Production. Diploma Thesis, Institute of Mineralogy and Economic Geology, University Aachen, Germany

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United Nations International Framework Classification for Reserves/Resources, Solid Fuel and Mineral Commodities, Final Version

UN international Framework	Detailed Exploration	General Exploration	Prospecting	Reconnaissance
Mining	MINED 1986 - 1997 61,234 tonnes U3O8			
Feasibility	1 (111) IREM-MERI 1980 55,160 tonnes U3O8			

DEILMANN DEPOSIT

UN international Framework	Detailed Exploration	General Exploration	Prospecting	Reconnaissance
Mining	MINED 1983 - 1987 22,971 tonnes U3O8			
Feasibility	1 (111) IREM-MERI 1980 29,965 tonnes U3O8			
Pre-feasibility	1-2 (121) EBC / UEB 1977 - 1978 18,410 tonnes U3O8			
Geology	same as pre-feasibility	2 (332) URANERZ 1975 > 10,000 tonnes U3O8	? (333)	? (334)

GÄRTNER DEPOSIT

Economic Viability Categories:
1 = economic; 1-2 = economic to potentially economic; 2 = potentially economic; ? = undetermined
(211) = code for UN International Framework for Reserves/Resources

TABLE 1
UNITED NATIONS INTERNATIONAL FRAMEWORK FOR RESERVE/RESOURCE CLASSIFICATION,
KEY LAKE

	Cut-off (%)	Ore tonnage (tonnes)	Grade (%U3O8)	Uranium content (tonnesU3O8)	Uranium content compared to mine production (%)
IREM-MERI 1979 (radiometric)	0.15	1,726,775	3.15	54,445	-11.09
IREM-MERI 1980 (chemical)	0.15	1,759,710	3.13	55,160	-9.9
BLAST HOLES 1997	0.20	2,582,097	2.19	56,565	-7.6
ACTUAL MINE PRODUCTION (1986-1997)	0.20	2,486,609	2.46	61,234	

DEILMANN DEPOSIT

	Cut-off (%)	Ore tonnage (tonnes)	Grade (%U3O8)	Uranium content (tonnesU3O8)	Uranium content compared to mine production (%)
UEB/EBC 1977/78	0.10	539,100	3.41	18,410	-19.86
IREM-MERI 1979 (radiometric)	0.15	746,125	3.65	27,225	18.52
IREM-MERI 1979 (chemical)	0.15	801,875	3.74	29,965	30.45
GEOSTATS 1985	0.20	589,710	3.93	23,156	0.81
ACTUAL MINE PRODUCTION (1983-1987)	0.20	1,230,587	2.18	22,971	

GÄRTNER DEPOSIT

TABLE 2
RESERVES ESTIMATION KEY LAKE DEPOSITS

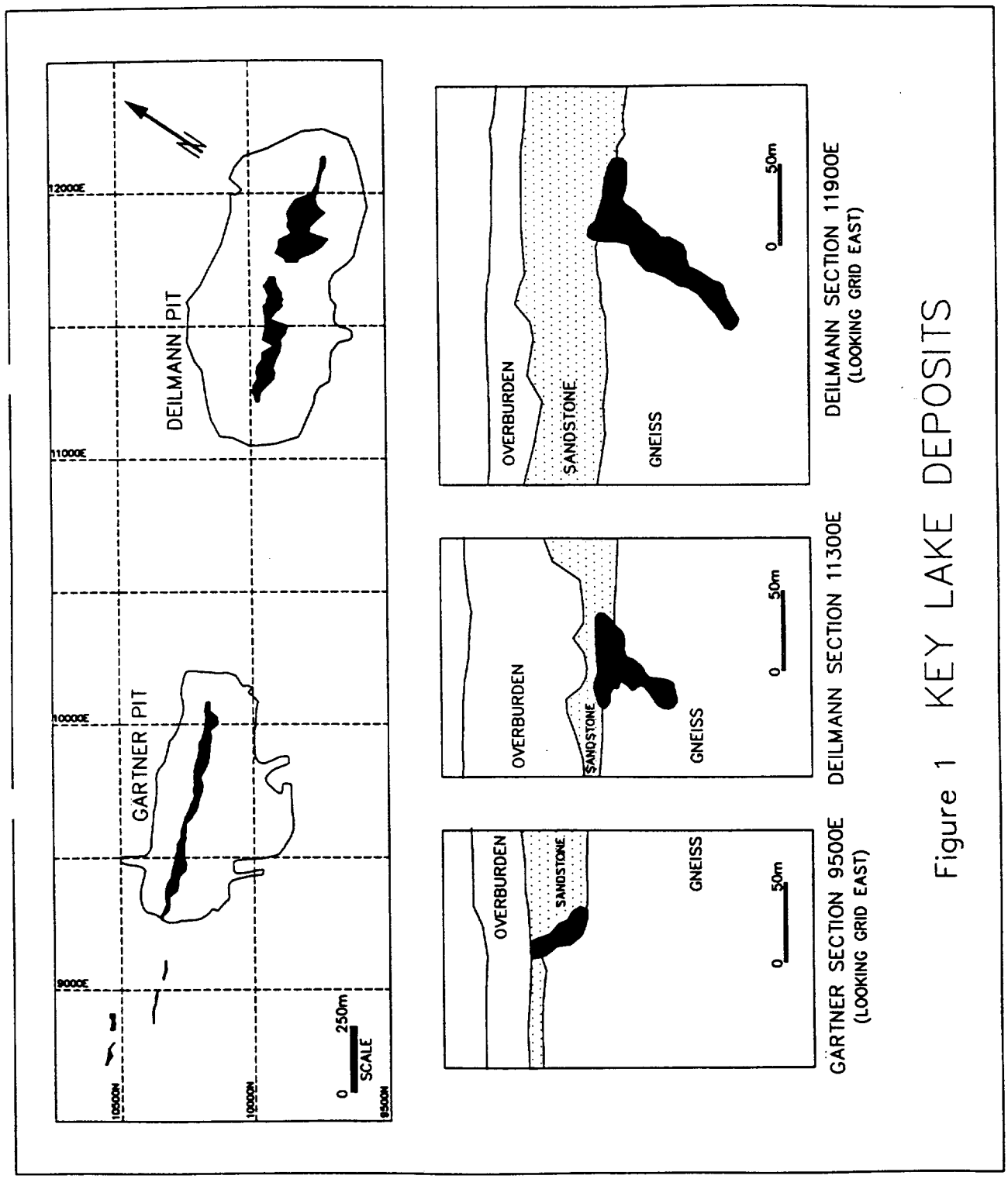

Figure 1 KEY LAKE DEPOSITS