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Application of the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 to the Uranium Resources of the Gurvanbulag Uranium Deposit, Mongolia

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Summary

This document provides a case study of the Gurvanbulag Uranium Deposit in north-eastern Mongolia. An overview of three uranium resource estimations conducted at different stages of the development of the Gurvanbulag Deposit is given. The case study demonstrates that quantities reported under the Classification of Reserves for Solid Minerals of the Former Soviet Union (FSU) (1981) and the Committee for Mineral Reserves International Reporting Standards (CRIRSCO) Template can be unified and classified under the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 (UNFC-2009). Moreover, the granularity offered by UNFC-2009 can be used to describe the project more precisely, especially in relation to project status, feasibility and socio-economic viability.

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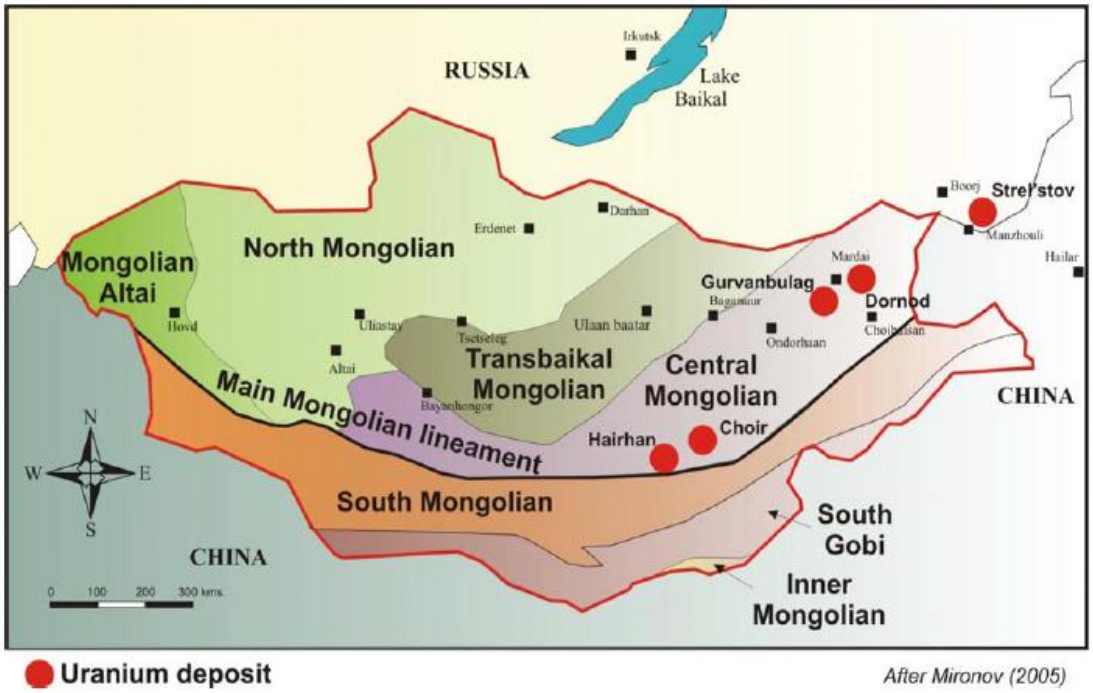
I. Introduction

1. This case study was prepared by Mr. Shengxiang Li of the China National Nuclear Corporation, with the technical input of Mr. Harikrishnan Tulsidas of the International Atomic Energy Agency (IAEA).

2. The Gurvanbulag Uranium Deposit lies within the Saddle Hills property, which is located in Dornod Aimag in north-eastern Mongolia, approximately 100 km from the border of Mongolia with Russia to the north, and also 100 km from the border with China to the east. The deposit lies approximately 780 km north-east of the capital Ulaanbaatar with coordinates 49°03'N and 114°00'E. Geologically, the Gurvanbulag Uranium Deposit is located in the Central Mongolia metallogenic belt (Figure 1).

Figure 1
Regional location map of the Gurvanbulag Uranium Deposit. After [1]



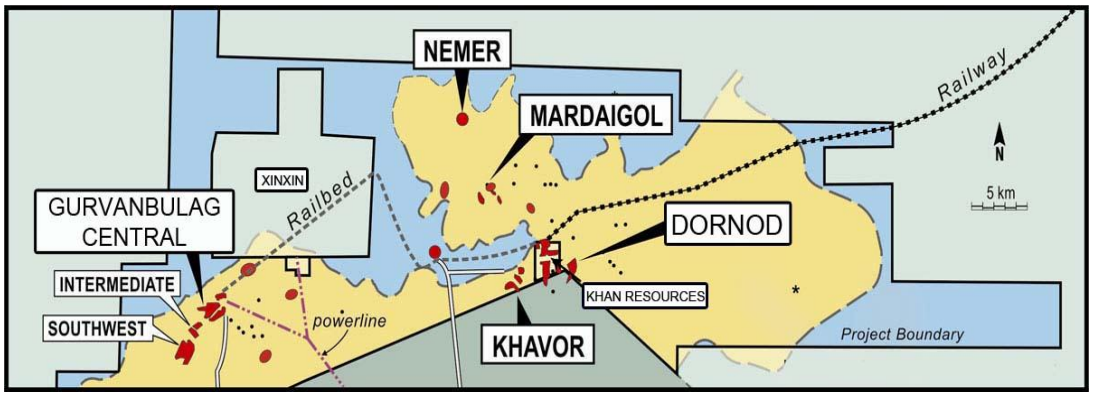
3. The Gurvanbulag Uranium Deposit comprises three parts, namely, the Central Zone, Intermediate Zone and South-west Zone (Figure 2).

4. The deposit was discovered and developed by the Ministry of Geology of the Former Soviet Union (FSU). Exploration work was conducted by FSU geologists between 1944 and 1989. Polymetallic mineralization was identified in 1945.

5. Prospecting for uranium in the Choibalsan area began in 1971 with the first reference to uranium occurrences in the district in 1975, when radiometric surveys identified uranium anomalies. Subsequent to these surveys, a number of regional and local exploration programmes were conducted, including geological mapping at 1:50,000 and 1:200,000 scales, airborne and ground spectrometric surveys, geochemistry and trenching.

Figure 2

Location map of the Gurvanbulag Uranium Deposit within the Saddle Hills Property. After P&E Mining Consultants Inc. (2009) [2]



6. The Gurvanbulag Uranium Deposit was explored and developed in the 1970s and 1980s. Initially surface drilling was drilled at 200 x 100 m^2 spacing with detailed follow-up of 100 by 50 m^2 grids in areas identified as mineralized. All holes were radiometrically logged.

7. Underground development at the Gurvanbulag Deposit comprised three vertical shafts with the deepest descending to approximately 287 metres (m), with limited development on the 140 m (+920 FSU level) and 200 m levels (+860 FSU level) with most development on the 260 m level (+800 FSU level).

8. Underground diamond and percussion drilling at the Gurvanbulag Deposit targeted a grid of 25 by 25 m^2 but in many areas as holes fanned out from levels above and below the zone spacing along the sections was closer to 10 m.

9. In 1973–1987, FSU geologists conducted a significant amount of geological and geophysical work in the Gurvanbulag Deposit and its neighbouring area, including 654,000 m of drilling, 258,100 m^3 of trenching and generation of over 5,000 samples [3].

10. In the early 1990s, the property was abandoned with the withdrawal of all personnel from Mongolia following the collapse of the FSU. All surface facilities relating to the development of the Gurvanbulag Deposit were removed and all shafts were capped with concrete.

11. In 2004, Western Prospector Group Limited (Western Prospector), a Canadian company based in Vancouver, British Columbia, acquired the property. The property was operated by Emeelt Mines LLC. The Gurvanbulag Mine was dewatered in the second half of 2006 and underground exploration and sampling were initiated.

12. In 2004–2008, Western Prospector Group Limited carried out a large amount of geological work in the property area to verify the FSU geologists' exploration results, to carry out infill drilling which upgraded the resources and to undertake a feasibility study, including 68,625 m of drilling and the generation of 3,464 samples.

13. Following underground exploration and further surface drilling, P&E Mining Consultants Inc. (P&E) was engaged to prepare a new mineral resource estimate which was completed in November 2008 [2].

14. In 2009, CNNC International Limited, which is a subsidiary company of the China National Nuclear Corporation (CNNC), acquired the property, and became the operator of the project. This study attempts to unify the resource estimates under the Committee for Mineral Reserves International Reporting Standards (CRIRSCO) Template and the FSU

Classification of Reserves for Solid Minerals of 1981 through the application of the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 (UNFC-2009).

II. Geology and resource estimates

A. Geology

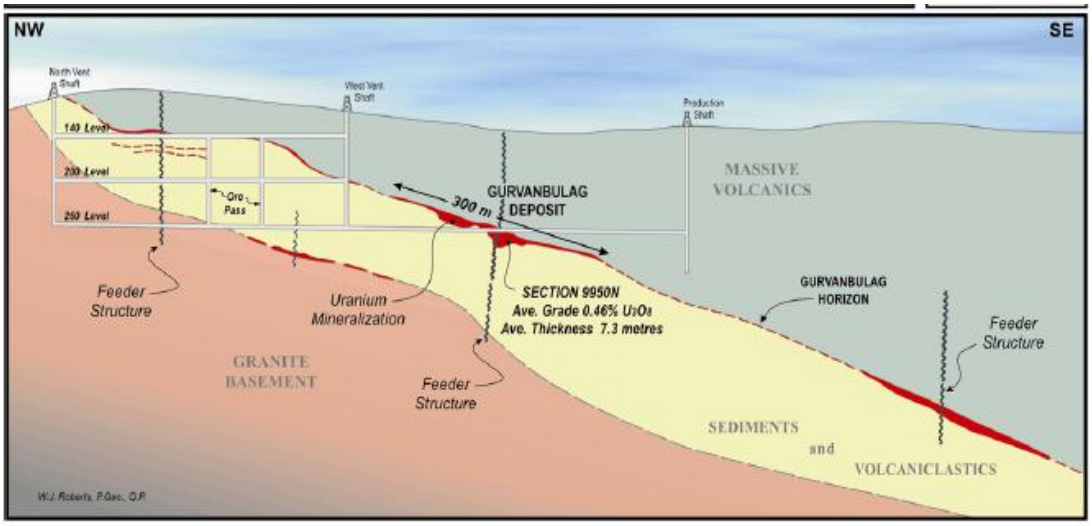
15. The Gurvanbulag Deposit occurs in Mesozoic volcanic rocks located within a uranium province that extends into Russia (Figure 1) and includes the uranium deposits of Strel'tsov in Russia. The Gurvanbulag Deposit shares many similarities with the Strel'tsov deposits but differs in that the majority of the mineralization shows strata-bound characteristics.

16. The deposit falls within the broad classification of a volcanic-related uranium deposit with a uranium-molybdenum-fluorine (U-Mo-F) association. Common to all uranium deposits in volcanic rocks is their occurrence in a bimodal suite of rocks consisting of large amounts of high silica rhyolites which overlie intermediate and basaltic units. The deposit differs from other volcanic-related uranium deposits by being associated with a laterally extensive volcanic glass horizon and extensive bedding conformable mineralization.

17. Uranium mineralization at the Gurvanbulag Deposit occurs in extensively altered, hydro-mica rich clays occurring immediately above and below the obsidian horizon underlying massive felsitic ignimbrites, dipping 5–20 degrees to the south-east (Figure 3). Minor localized mineralization occurs in steeply dipping faults in the overlying ignimbrites and as small strata-bound deposits below the main Gurvanbulag horizon.

18. The coefficients of variance in grade of the ore bodies in the Gurvanbulag Deposit range between 1.83 and 2.7 (% U)^2, indicating a high complexity of the Deposit.

Figure 3
A schematic profile of the Gurvanbulag Deposit. After [4]



B. Resource estimates

19. Three significant uranium resource estimations were conducted previously for the Gurvanbulag Deposit.

20. The first resources estimation was completed by FSU geologists in 1988 [3]. The in-situ resource was estimated using the polygonal estimation method at a cut-off grade of 0.04% U and a minimum minable thickness of 0.7 m. Table 1 summarizes the C1 and C2 category resources of the Gurvanbulag Deposit (Central, Intermediate and South-west) defined by the FSU. These estimates are not completely compatible with Mineral Resources and Mineral Reserves as defined under the CRIRSCO family of codes and standards, such as the Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves ('the Joint Ore Reserves Committee (JORC) Code') or the Canadian Institute of Mining, Metallurgy and Petroleum (CIM) Definition Standards on Mineral Resources and Mineral Reserves as incorporated into Canadian Securities Administrators (CSA) National Instrument 43-101 (NI 43-101).

Table 1
Uranium resources in the Gurvanbulag Deposit according to the FSU Classification of Reserves for Solid Minerals, as of July 1987 [3]

Area	*Category*	*Ore（kilotonne (kt))*	*% U*	*tU*
Central Zone	C1	4,214	0.208	8,761
	C2	3,204	0.118	3,788
	Subtotal	**7,418**	**0.169**	**12,549**
Intermediate Zone	C2	2,690	0.104	2,800
South-west Zone	C2	451	0.16	724
Total	C1	4,214	0.208	8,761
	C2	6,345	0.115	7,312
	C1+C2	**10,560**	**0.152**	**16,073**

21. The Russian Code for the Public Reporting of Exploration Results, Mineral Resources and Mineral Reserves (NAEN Code) [5] provides a mapping of the current 2008 Russian Mineral Reporting Standards (which is derived from the FSU Classification of Reserves for Solid Minerals of 1981) and the CRIRSCO Template, which indicates that C1 in deposits of the 1st, 2nd and 3rd complexity groups can be equivalent to Measured Resources, and C1 in deposits of the 4th complexity can be equivalent to Indicated Resources. C2 in the Russian system is also considered equivalent to Indicated Resources. Inferred Resources are mapped to P1 resources of the Russian system [5]. However, this study, based on the application of UNFC-2009 principles and specifications, conservatively assigns the category C2 resources reported in the FSU classification system as being equivalent to Inferred Resources.

22. In November 2006, on behalf of Western Prospector, SRK Consulting (Canada) Inc. prepared a NI 43-101 compliant Mineral Resource estimate for the Central Zone of the Gurvanbulag Deposit. [4]. The primary objective of the SRK Consulting report was to prepare an independent estimate of uranium resources that is compliant with the CIM Definition Standards on Mineral Resources and Mineral Reserves. The SRK Consulting estimate was based on a dataset that combined both FSU data and new data collected by Western Prospector/Emeelt Mines in the 2005–2006 drill programme; the drill data included holes drilled by Western Prospector/Emeelt Mines to mid-March 2006 [4]. The

previous FSU data was largely supported by an additional 110 confirmation diamond drill holes completed by Western Prospector.

23. SRK Consulting reported mineral resources for the Central Zone of the Gurvanbulag Deposit at a cut-off grade of 0.07% U_3O_8 (0.059% U) and a minimum minable thickness of 1.5 m, based on a long-term uranium price of US $47 per pound U_3O_8 and its own internal estimate of potential operating costs for underground mining. Using conservative criteria only, a part of the C1 resources were considered as Indicated Resources and the rest were classified as Inferred Resources. The resource estimates under different categories are shown in Table 2.

24. Since the SRK Consulting resource estimation parameters (higher cut-off grade and thickness) are evidently more conservative than the previous FSU estimate, the total resources of the Central Zone of the Gurvanbulag Deposit estimated by SRK Consulting are somewhat smaller.

Table 2
Mineral Resources for the Gurvanbulag Central Zone, effective as of November 2006 [4]

Area	*Category*	*Ore (kt)*	*% U*	*tU*
Central Zone	Indicated	2,830	0.186	5,249
	Inferred	2,670	0.125	3,327
	Total	**5,500**	**0.156**	**8,576**

25. In November 2008, P&E Mining Consultants Inc., in conjunction with Aker Solutions (“Aker”), at the request of Western Prospector Group Ltd, conducted an updated resource estimation for the Gurvanbulag Central Zone and prepared an NI 43-101 compliant Technical Report and Definitive Feasibility Study on the Gurvanbulag Central Deposit, Saddle Hills Property [2].

26. A total of 2,220 FSU and Western Prospector drill holes including 40,457 m of diamond drilling and 8,360 m of reverse circulation drilling on surface, underground channels and gamma logged drill holes, were used in the resource modelling area.

27. The resource estimate was derived from applying a 0.08% U_3O_8 (0.068% U) cut-off grade and a 1.4 m minimum mineable thickness to the block model, reporting the resulting tonnes and grade for potentially mineable areas. In this estimate, more exploration data was made available, especially from underground channel sampling. Channel sampling on the 260 level was initiated in November 2006 and continued to March 2007. The objective of the underground sampling programme was to channel sample existing underground workings to fill a gap in the available FSU information and to provide a substantial quantity of new assay information for incorporation into an NI 43-101 compliant resource estimate. Underground geological mapping was also carried out to better understand the structural geology and nature of the ore body. Radiometric (gamma) logging was undertaken in the FSU-era diamond and percussion drill holes on the 260 level of the mine workings.

28. Additionally, 62 reverse circulation (RC) drill holes were drilled, totalling 8,360 m, out of which 54 were gamma logged. These are mainly infill drilling designed to convert the Inferred Resources of the SRK Consulting resource report (2006) to Indicated Resources by increasing the drillhole density. Additional exploration data and infill drilling promoted a part the SRK 2006 Indicated Resources to Measured Resources and a large part of Inferred Resources to Measured Resources. Table 3 shows the resource estimate results prepared by P&E for the Central Zone of the Gurvanbulag Deposit, effective as of 15 October 2008.

Table 3
Mineral Resources for the Gurvanbulag Central Zone effective as of 15 October 2008 [2]

Area	*Category*	*Ore（kt）*	*% U*	*tU*
Central Zone	Measured	774	0.205	1,579
	Indicated	3,510	0.151	5,313
	Measured & Indicated	**4,284**	**0.160**	**6,892**
	Inferred	795	0.107	847
	Total	**5,079**	**0.152**	**7,739**

29. The Gurvanbulag Deposit will be mined by underground mining techniques. The known potentially economic mineralization extends from the surface to approximately 500 m below surface elevation. A mining recovery of 95% and dilution of 20% was considered when P&E estimated the reserve for the Gurvanbulag Central Zone. Further, the Definitive Feasibility Study (DFS) converted the Measured and Indicated Resources into Proved and Probable Reserves based on mine geotechnical inputs and economic analysis. Inferred Resources were not considered in the DFS.

30. The process plant that has been designed for the Gurvanbulag operation is based on a Resin Extraction Process (REP). The first stage of processing is the sorting stage. This is followed by grinding, leaching, the resin extraction process and elution, product precipitation, and finally calcining and packaging. The processing recovery considered was around 95%. Table 4 shows the reserve estimate provided by P&E for the Central Zone of the Gurvanbulag Deposit, effective as of 15 October 2008.

Table 4
P&E Mineral Reserves for the Gurvanbulag Central Zone, effective as of 15 October 2008 [2] (after P&E, 2009)

Area	*Category*	*Ore (kt)*	*% U*	*tU*
Central Zone	Proved Reserves	914.5	0.168	1,538
	Probable Reserves	4,128.5	0.130	5,346
	Total Reserves	**5,043**	**0.137**	**6,884**

III. Uranium resource reporting aligning the Gurvanbulag Deposit to UNFC-2009

31. UNFC-2009 is a project-based system that applies to all fossil energy and mineral reserves and resources. It has been designed to meet, to the extent possible, the needs of applications pertaining to energy and mineral studies, resource management functions, corporate business process and financial reporting standards [6]. The transfer of quantities from the estimates reported previously to UNFC-2009 has been aided by the UNFC-2009 principles, Generic Specifications and the Bridging Document between the CRIRSCO Template and UNFC-2009. Further the uranium guidelines were also considered in the exercise [7].

32. According to the discussion above, there is a total of 11,255 tU of uranium resources, which is inclusive of 6,884 tU reserves in the Gurvanbulag Deposit. The Central Zone of the Gurvanbulag Deposit has 6,884 tU of Proved and Probable Reserves and

847 tU of Inferred Resources, the Intermediate Zone has 2,800 tU of C2 resources, and the South-west Zone has 724 tU of C2 resources (Table 5). The C2 resources of the FSU classification system have been conservatively assigned as Inferred Resources in this study.

33. In the Central Zone of the Gurvanbulag Deposit, 1,538 tU of Proved reserves can be classified as E1.1, F1.3, G1 (Table 5), and 5,346 tU of Probable Reserves can be classified as E1.1, F1.3, G2 using UNFC-2009 since detailed studies for demonstrating the feasibility of extraction have been completed and approved by CNNC and the Mongolian Government and their geological confidence level is high (for Proved Reserves) or moderate (for Probable Reserves). About 847 tU of inferred resources can be classified as E2, F2.1, G3 using UNFC-2009, since their geological confidence level is relatively low and project activities are ongoing to justify development in the foreseeable future.

34. There are an estimated 2,800 tU of C2 resources in the Intermediate Zone and 724 tU of C2 resources in the South-west Zone. These 3,524 tU of C2 resources can be also classified as E2, F2.1, G3 according to UNFC-2009. Table 5 shows all the uranium quantities according to UNFC-2009.

Table 5
Uranium reserves and resources of the Gurvanbulag Deposit classified according to UNFC-2009 (Effective date: 15 October 2008)

Area	*tU*	*% U*	*NI 43-101 or FSU Classification*	*UNFC-2009*	*UNFC-2009*	*UNFC-2009 Categories*		
				Class	*Sub-class*	*E*	*F*	*G*
Central Zone	1,538	0.168	Proved Reserves	Commercial Projects	Justified for Development	1.1	1.3	1
	5,346	0.13	Probable Reserves			1.1	1.3	2
	847	0.107	Inferred Resources	Potentially Commercial Projects	Development Pending	2	2.1	3
Intermediate Zone	2,800	0.104	C2	Potentially Commercial Projects	Development Pending	2	2.1	3
South-west Zone	724	0.16	C2	Potentially Commercial Projects	Development Pending	2	2.1	3

35. The definitions of the UNFC-2009 Categories used are as follows:

E1.1 Extraction and sale is economic on the basis of current market conditions and realistic assumptions of future market conditions.

E2 Extraction and sale is expected to become economically viable in the foreseeable future.

F1.3 Sufficiently detailed studies have been completed to demonstrate the feasibility of extraction by implementing a defined development project or mining operation.

F2.1 Project activities are ongoing to justify development in the foreseeable future.

G1, G2, G3 Quantities associated with a known deposit that can be estimated "with a high level of confidence" (G1), "with moderate level of confidence" (G2) and "with a low level of confidence" (G3).

IV. Conclusions

36. The key conclusions from the case study are provided as follows:

(a) This case study presents the historical progression of estimates, during the different Effective Dates and discusses the factors responsible for changes in the estimates over time. Three uranium resource estimations conducted at different development stages of the Gurvanbulag Deposit, by FSU geologists, SRK Consulting and P&E Mining Consultants, are based on significant drilling, analytical data and exploration work. The uranium resources estimated by P&E Mining Consultants [5] for the Gurvanbulag Central Zone are less than the earlier FSU estimates. The differences are due to the use of a higher cut-off grade and thickness and additional data made available as a result of the exploration carried out during 2004–2008. Application of UNFC-2009 principles and specifications makes the comparison of estimates consistent and reliable.

(b) For the Gurvanbulag Deposit, the category C1 resources of the FSU classification system can be viewed as equivalent to Indicated Resources of the CRIRSCO Template and the category C2 resources can be viewed as equivalent to Inferred Resources.

(c) The case study of the Gurvanbulag Deposit demonstrates that quantities reported under the FSU classification system and the CRIRSCO Template can be unified and classified under UNFC-2009. Moreover, the granularity offered by UNFC-2009 is useful to describe the project more precisely, especially in relation to project status, feasibility and socio-economic viability.

References:

[1] Mironov Y.B. (2005): Uranium of Mongolia. English translation, Center for Russian and Central EurAsian Mineral Studies (CERCAMS), London.

[2] P&E Mining Consultants Inc.(2009): Technical Report and Feasibility Study on the Gurvanbulag Uranium Deposit Saddle Hills Property, Dornod Province, Mongolia, for Western Prospector Group Ltd, February 20, 2009.

[3] Rogov Y.G., Yurchenko I.A. & al. (1987): Report on the results of detailed surveys in 1982-87 with calculation of reserves as of July 1, 1987. Ministry of Geology of the former Union of Soviet Socialist Republics (USSR) - All-Union Geological Prospecting Association "Sosnovskoye" Order of Lenin PGO - Mongolian Geological Mapping Expedition. Irkutsk. Mongolian Geo-information Centre Report # 5251.

[4] SRK, 2006: Independent Technical Report and Resource Estimate for the Gurvanbulag Deposit; Saddle Hills Uranium Project, Mongolia, 17 November 2006.

[5] Russian Code for the Public Reporting of Exploration Results, Mineral Resources and Mineral Reserves (NAEN Code) Available at http://www.crirsco.com/news_items/naen_code.pdf.

[6] United Nations Economic Commission for Europe (ECE) (2013) United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009

incorporating Specifications for its Application (ECE ENERGY SERIES No. 42) available at:http://www.unece.org/fileadmin/DAM/energy/se/pdfs/UNFC/pub/UNFC2009_Spec_ES42.pdf.

[7] ECE (2015) Guidelines for Application of the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 for Uranium and Thorium Resources, Prepared by the Expert Group on Resource Classification, available at: http://www.unece.org/fileadmin/DAM/energy/se/pdfs/comm24/ECE.ENERGY.2015.7_e.pdf.