Australian Aid

AMEP
Australia Mongolia Extractives Program

# Coalbed Methane Resources of Mongolia

## Methods, Results, Recommendations

Ulaanbaatar, Mongolia

**Tim A Moore,** Managing Director, Cipher Consulting Pty Ltd

15 June 2022

*Cipher Doc#: 22-419*


# Purpose of Course

- Consider what overall goals are for any resource assessment
- Review the Scope and Goals of THIS resource assessment
- Review resource classifications and concept of analogue
- Review resource estimate techniques
- Hydrogeology
  - *Concepts for CBM*
  - *Water production*
  - *Mongolian examples*
- **Review of Methods and Results of THIS resource assessment**
- **Next steps: Recommendations**

# Workshop Timetable

| Coalbed Methane Resources of Mongolia Workshop | | | | |
|---|---|---|---|---|
| from | To | total time (hr:min) | Topic | Presenter |
| 9:00 | 9:15 | 0:15 | **Opening Remarks** | |
| **9:15** | **10:45** | **1:30** | **BACKGROUND** | **Tim A Moore** |
| 9:15 | 9:30 | 0:15 | Goals of Any Resource Assessment | |
| 9:30 | 9:45 | 0:15 | Scope and Goals of This Resource Assessment | |
| 9:45 | 10:15 | 0:30 | Resource Classification (OGIP vs Prospective Resources) and Concept of an Analogue | |
| 10:15 | 10:45 | 0:30 | Resource Estimation Techniques Review | |
| 10:45 | 11:00 | 0:15 | **Coffee Break** | |
| **11:00** | **13:00** | **2:00** | **HYDROGEOLOGY** | **Ryan D Morris** |
| 11:00 | 11:30 | 0:30 | - Hydrogeology concepts for CBM | |
| 11:30 | 12:00 | 0:30 | - Case Study: Australia | |
| 12:00 | 12:30 | 0:30 | - What Happens With Water During Production | |
| 12:30 | 13:00 | 0:30 | - Mongolian Examples | |
| 13:00 | 14:00 | 1:00 | **LUNCH** | |
| **14:00** | **17:00** | **3:00** | ***REVIEW OF METHODS AND RESULTS OF RESOURCE REPORT*** | **TAM** |
| 14:00 | 14:40 | 0:40 | - Delineation of Areas for Assessment and Selection Criteria | |
| 14:40 | 15:10 | 0:30 | - Data Types and Limitations | |
| 15:10 | 15:30 | 0:20 | - Evaluation & Input Parameters | |
| 15:30 | 15:45 | 0:15 | **Coffee Break** | |
| 15:45 | 16:30 | 0:45 | - Results of Assessment | |
| 16:30 | 16:50 | **0:20** | ***NEXT STEPS, RECOMMENDATIONS & DISCUSSION*** | **TAM, All** |
| 16:50 | 17:00 | 0:10 | ***Closing Remarks*** | |

NOTE: Times are in UB, Mongolian Times

# Key Input Parameters

- Surface area (i.e. area of assessment) – $km^2$
- Thickness – net coal thickness of target - m
- Density - $g/cm^3$
- Gas Content – $m^3/t$

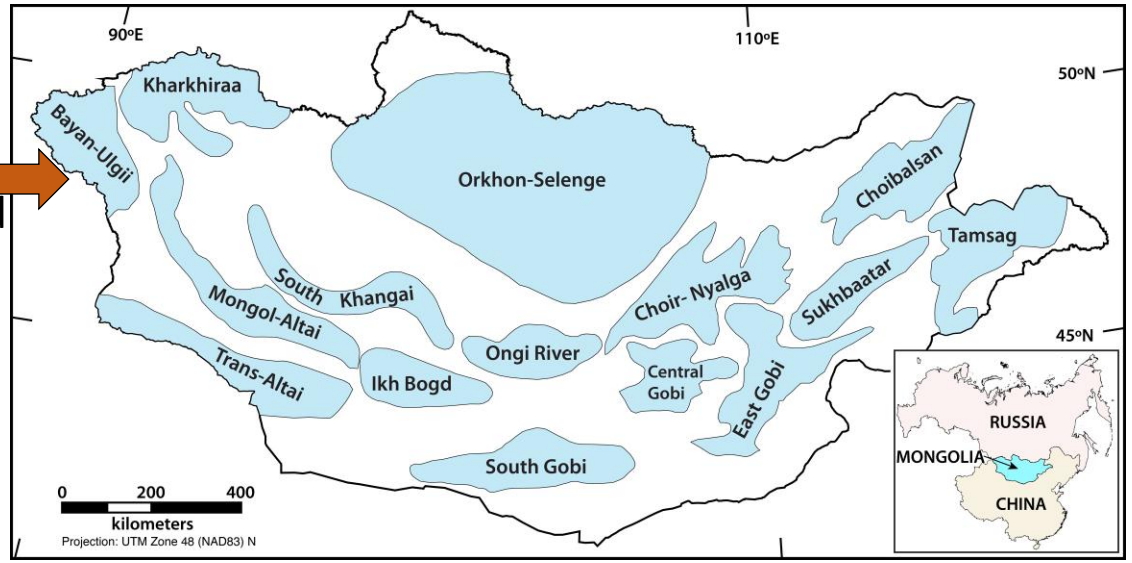
# Selecting Assessment Areas

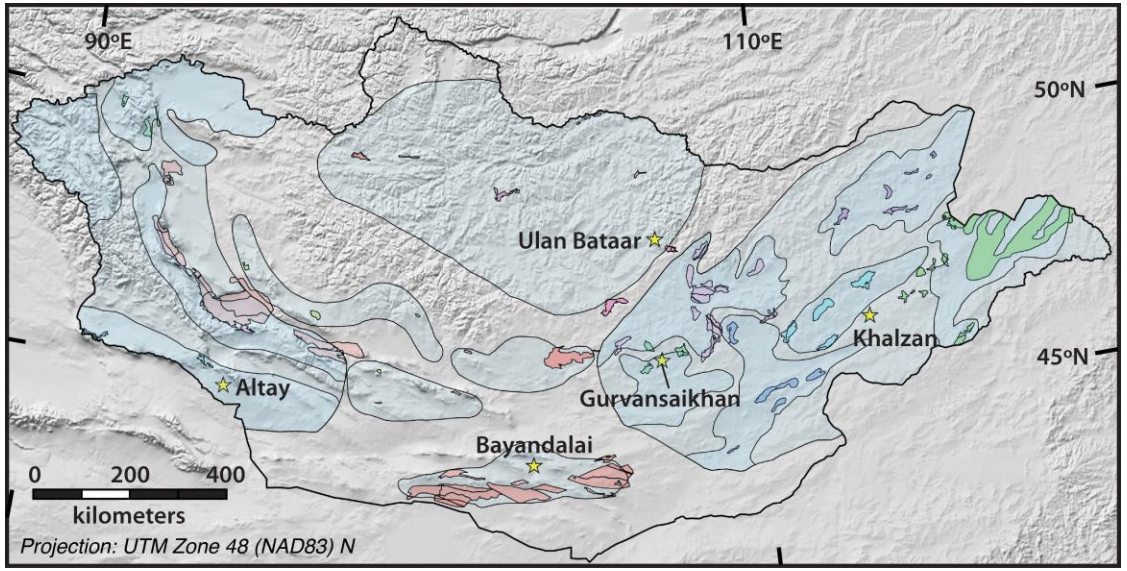
## Criteria:

- Known coal occurrence
- Data delineating thickness
- A conservative approach for extent
- The approach was to assess only the most likely areas with relatively good confidence in data; it is hoped that further work on each individual area will allow them to be enlarged, and thus significantly increasing gas resources

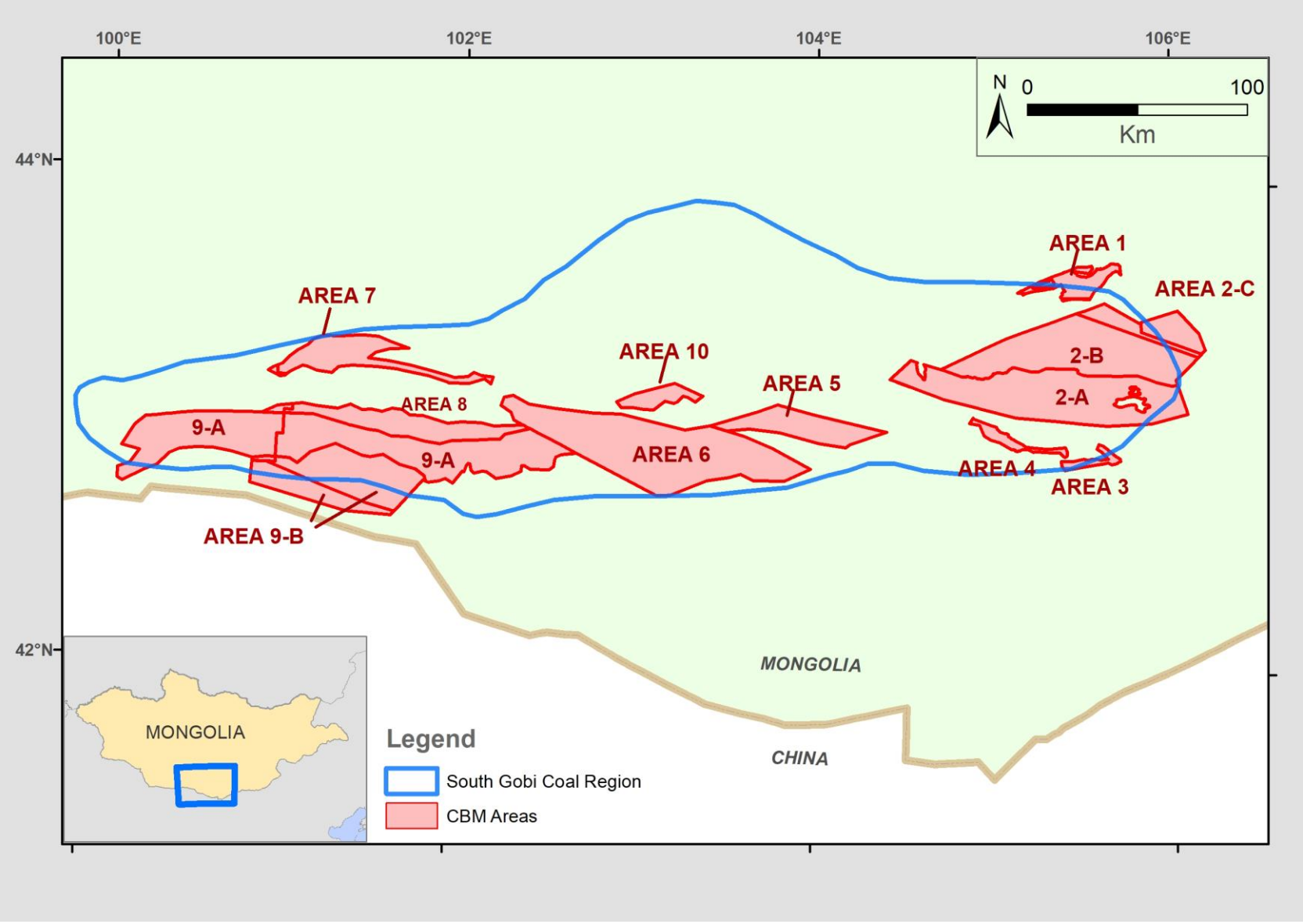
Bayan-Ulgii

Not assessed



# Review of Area Selection




## South Gobi

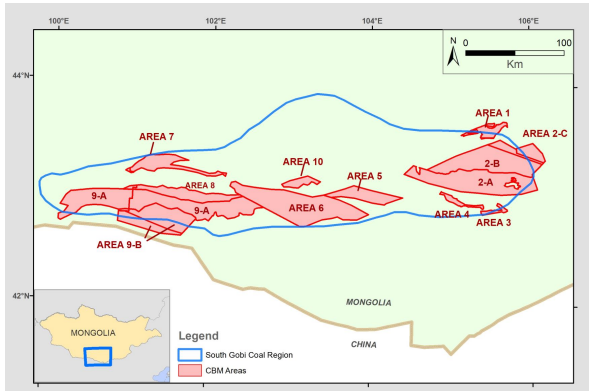
- Areas are large, from 150 to 3,283 km$^2$
- A total of 10 well defined areas
- Multiple age reservoirs
- Rank ranges subbituminous to medium volatile bituminous

# Review of Area Selection




**South Gobi**

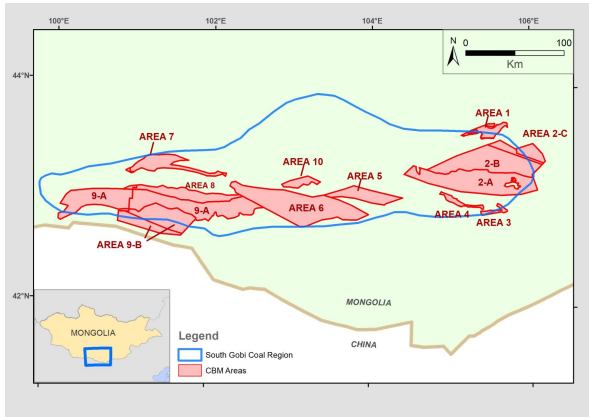
- Geological mapping
- Drill hole
- Mines



# Review of Area Selection


**South Gobi**

- Geological mapping
- Drill hole
- Mines

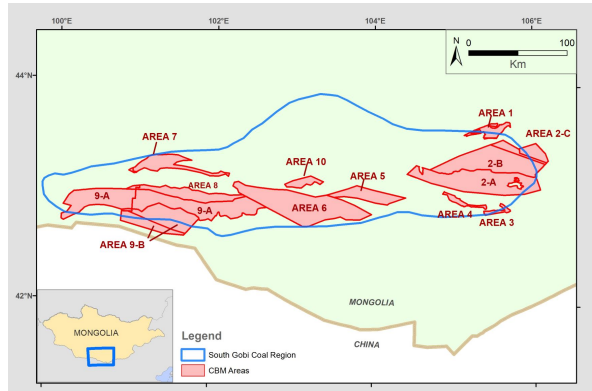


# Review of Area Selection


Restricted areas

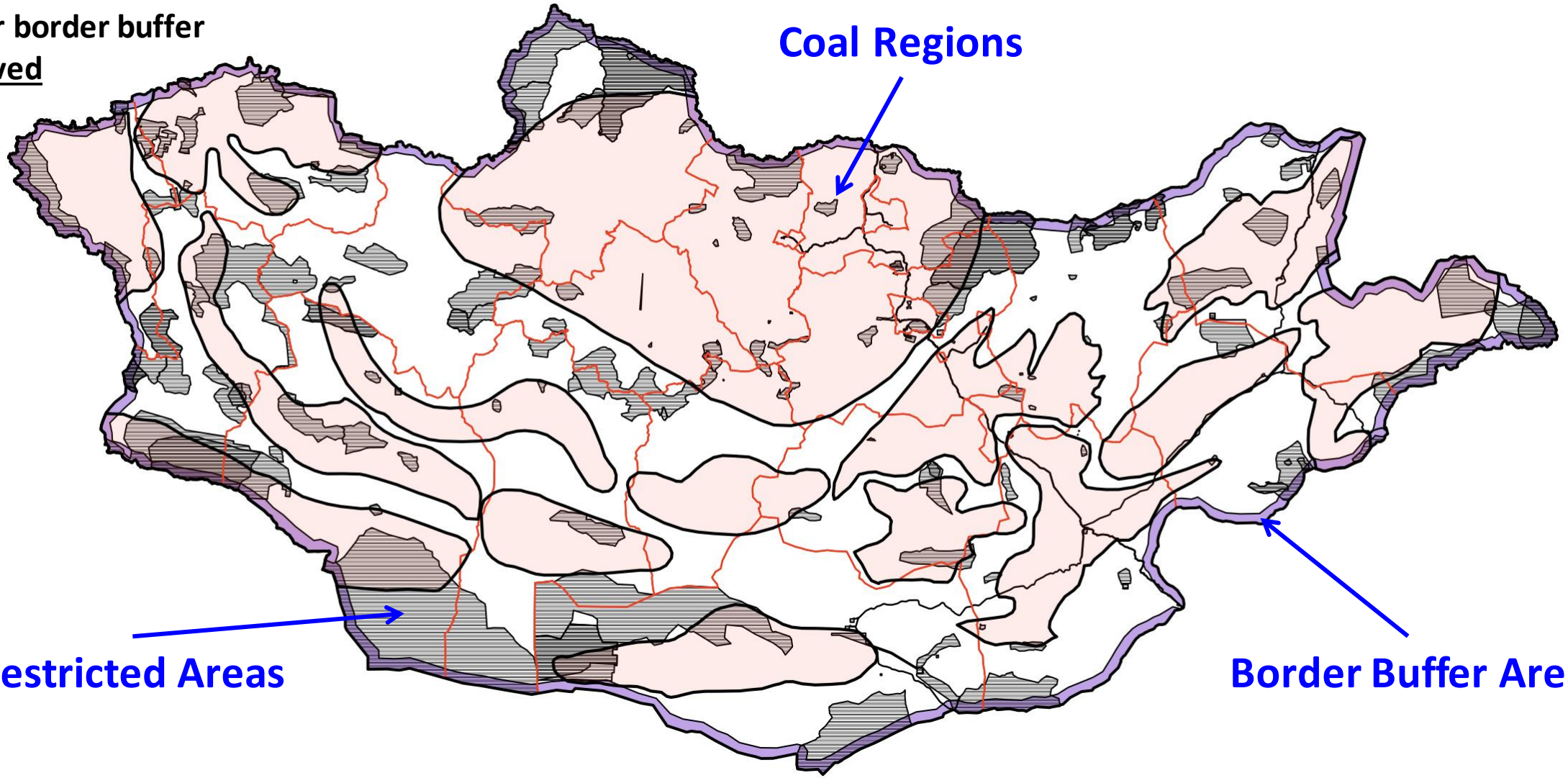
**South Gobi**

- For Prospective Resources, restricted areas were removed



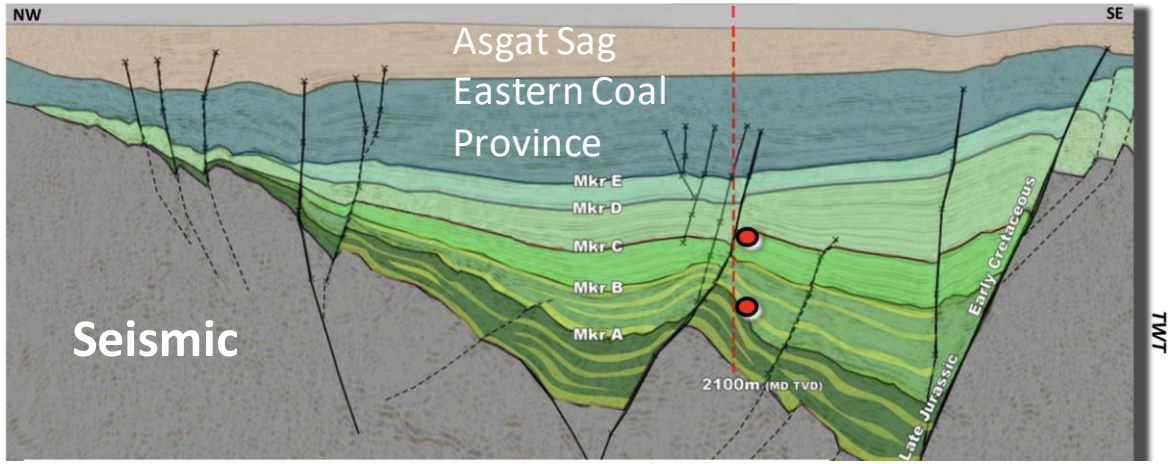
# Review of Area Selection

**Prospective Resources have restricted or border buffer areas <u>removed</u>**

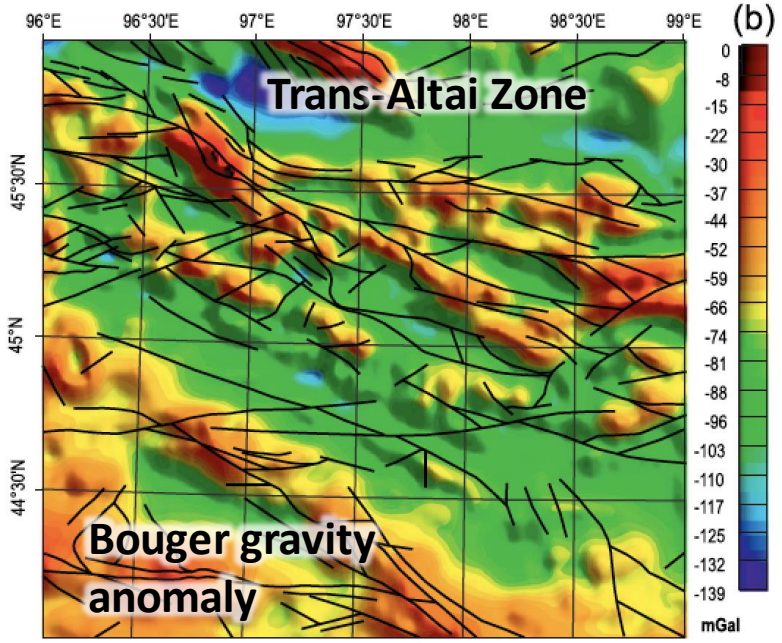


# Review of Area Selection

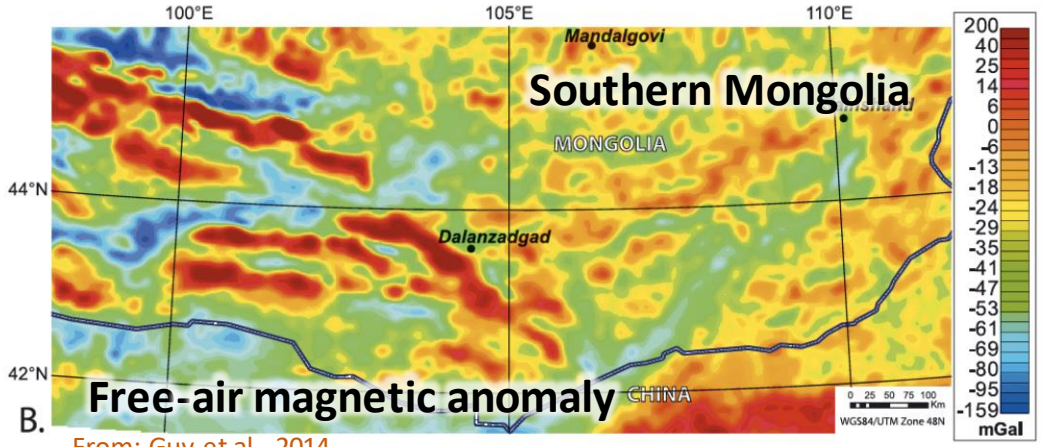
## What was not conducted in area selection




From: https://www.petromatadgroup.com/wp-content/uploads/2019/06/Corporate-Presentation-28_06_19-Petro-Matad.pdf

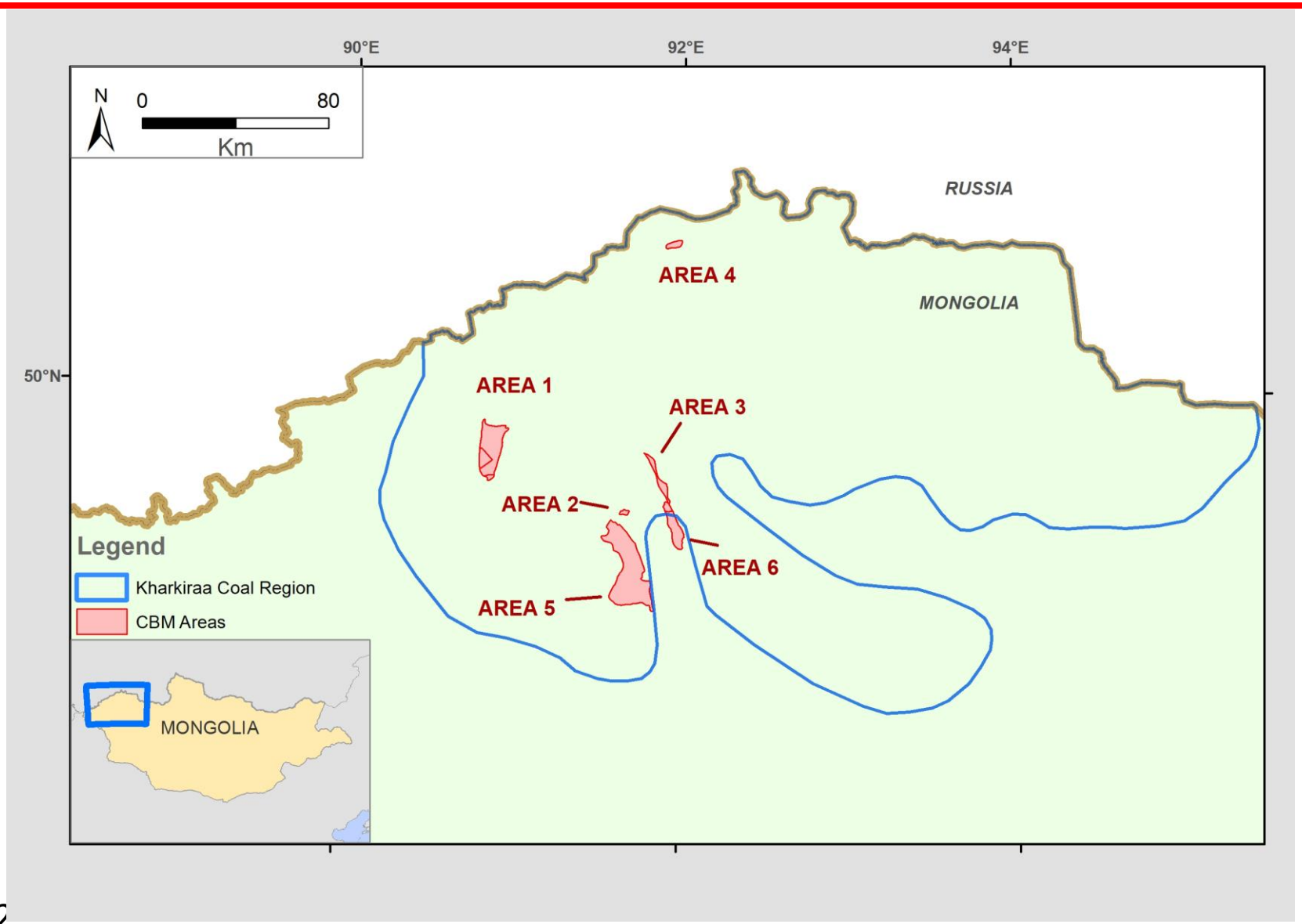



From: Hanžl et al., 2020




From: Guy et al., 2014

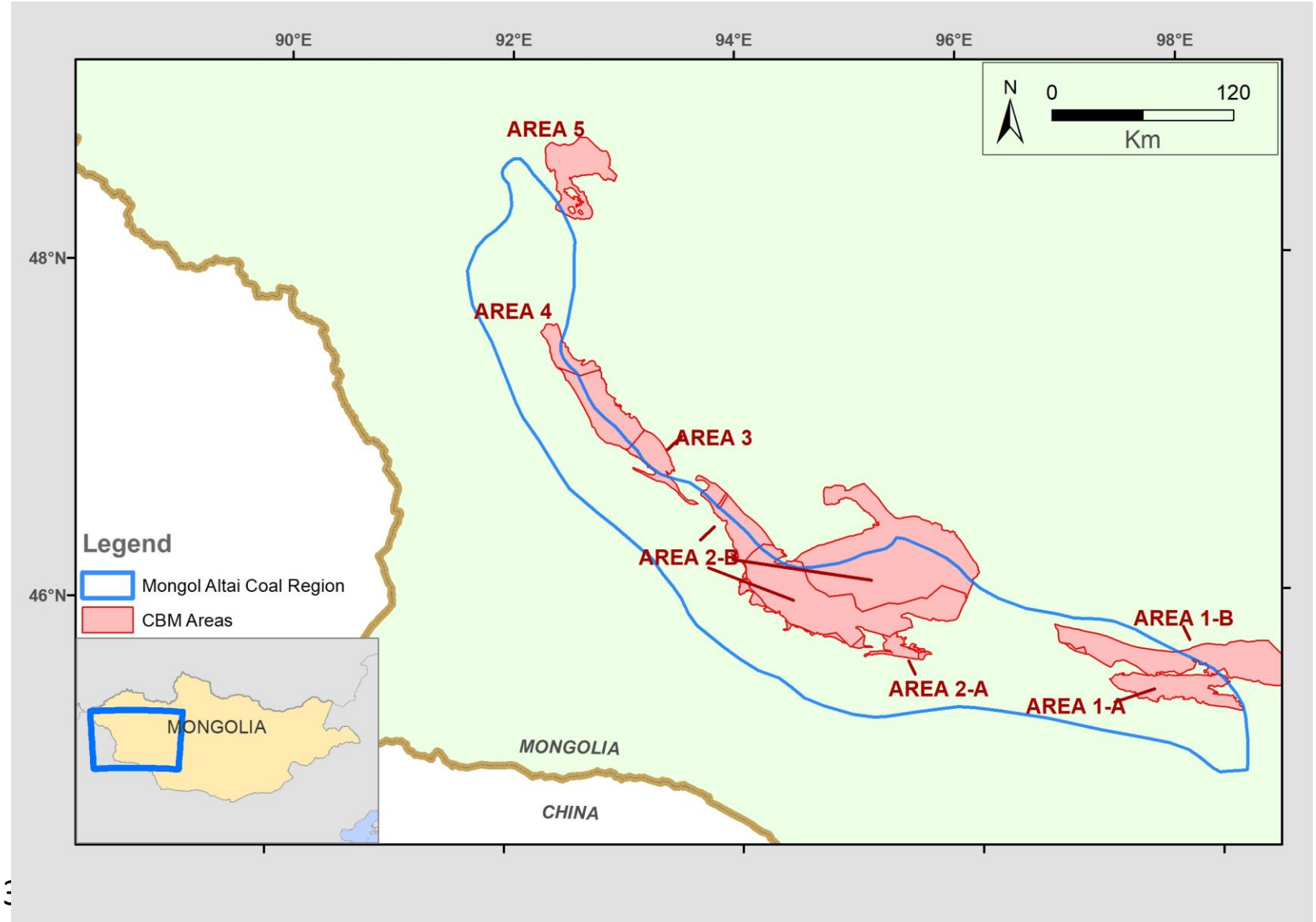
# Review of Area Selection




## Kharkhiraa

- 6 Areas assessed
- Individual areas range in size from 7 to 396 km$^2$
- Most areas are bituminous in rank, although some may be subbituminous.

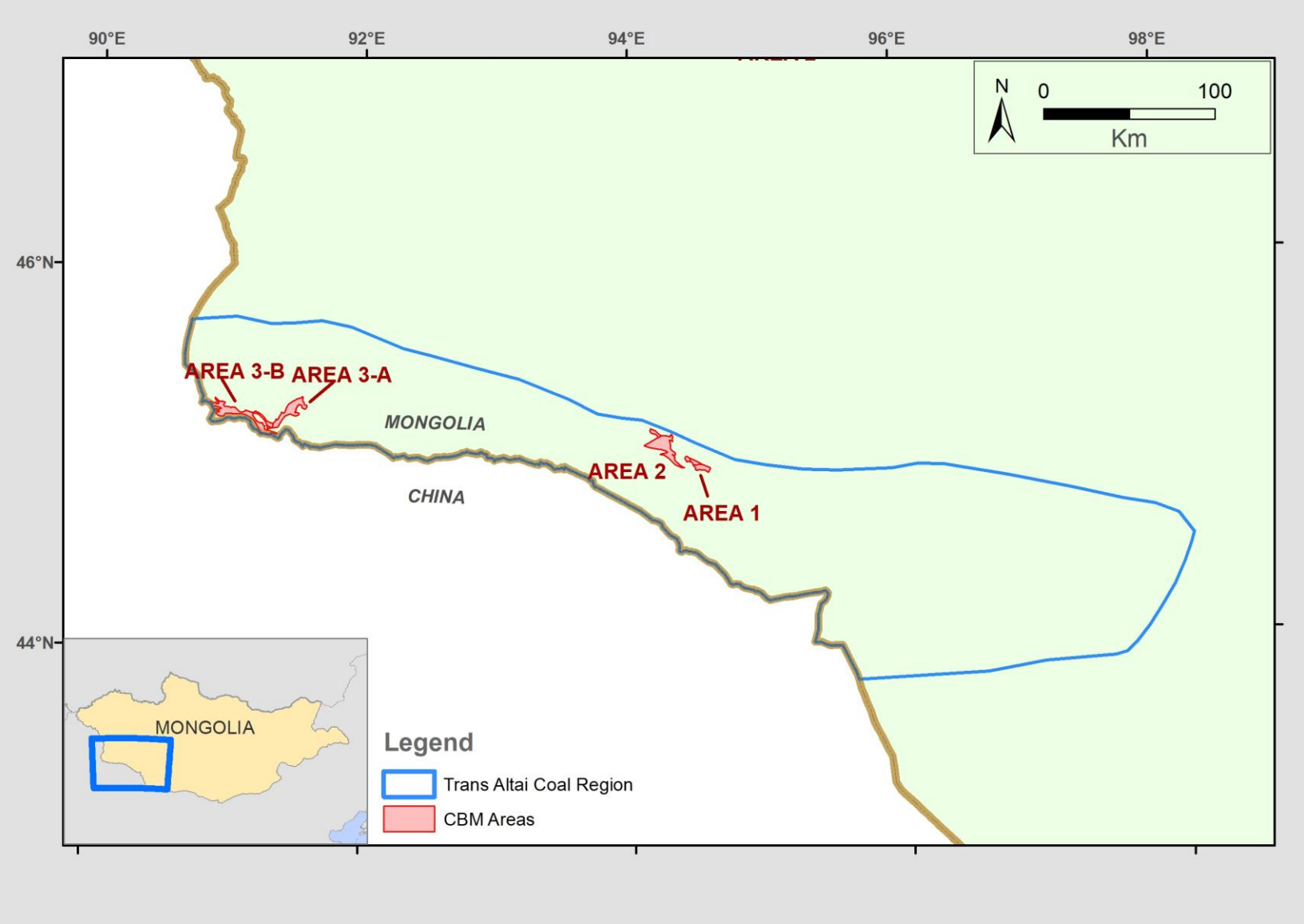
# Review of Area Selection




## Mongol-Altai

- 5 Areas assessed
- Range in size from 260 to 6,481 km$^2$
- Areas range in rank from subbituminous to possibly low volatile bituminous

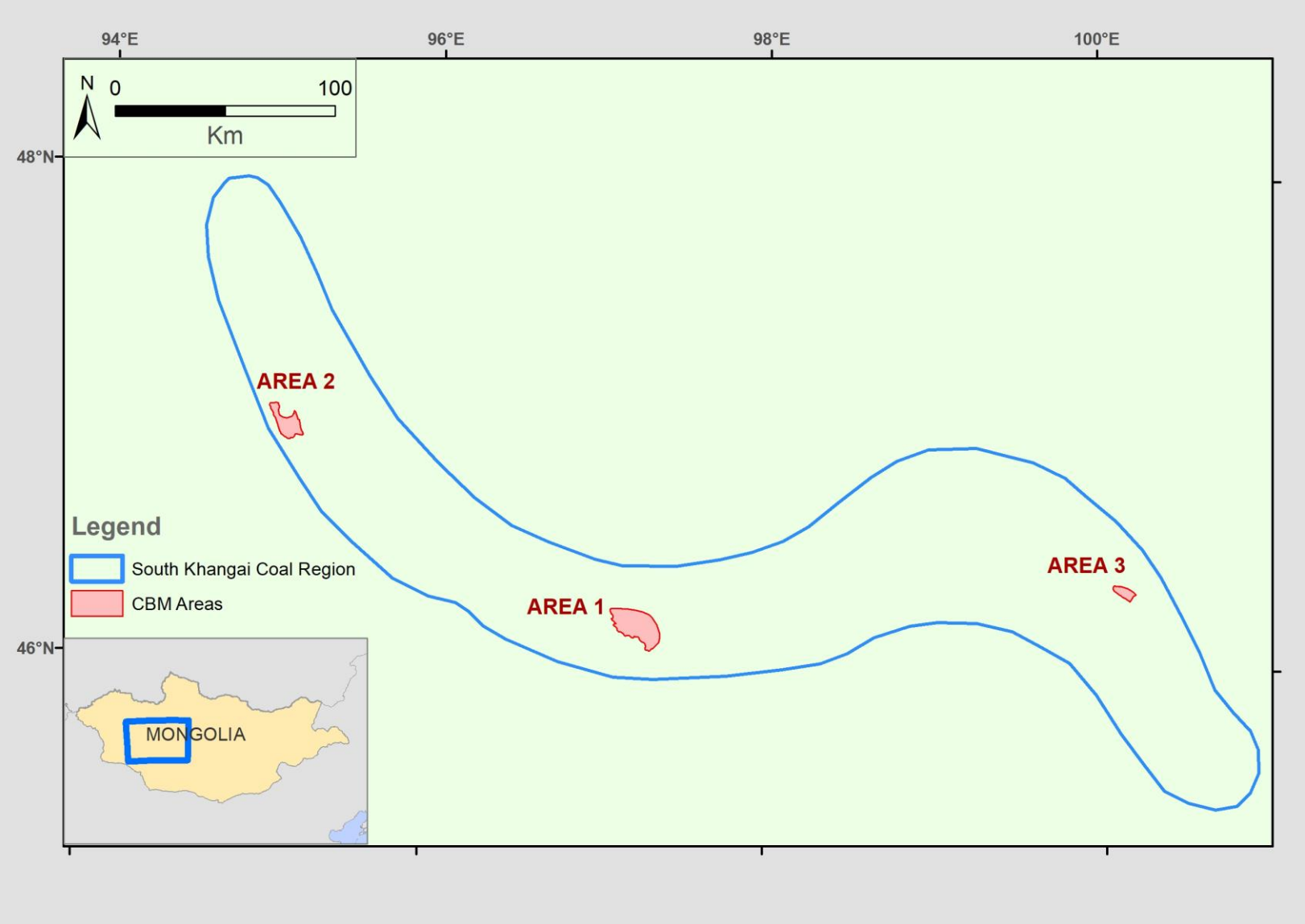
# Review of Area Selection




## Trans-Altai

- 3 Areas assessed
- Range in size from 45 to 250 $km^2$
- Areas range in rank from high to low volatile bituminous

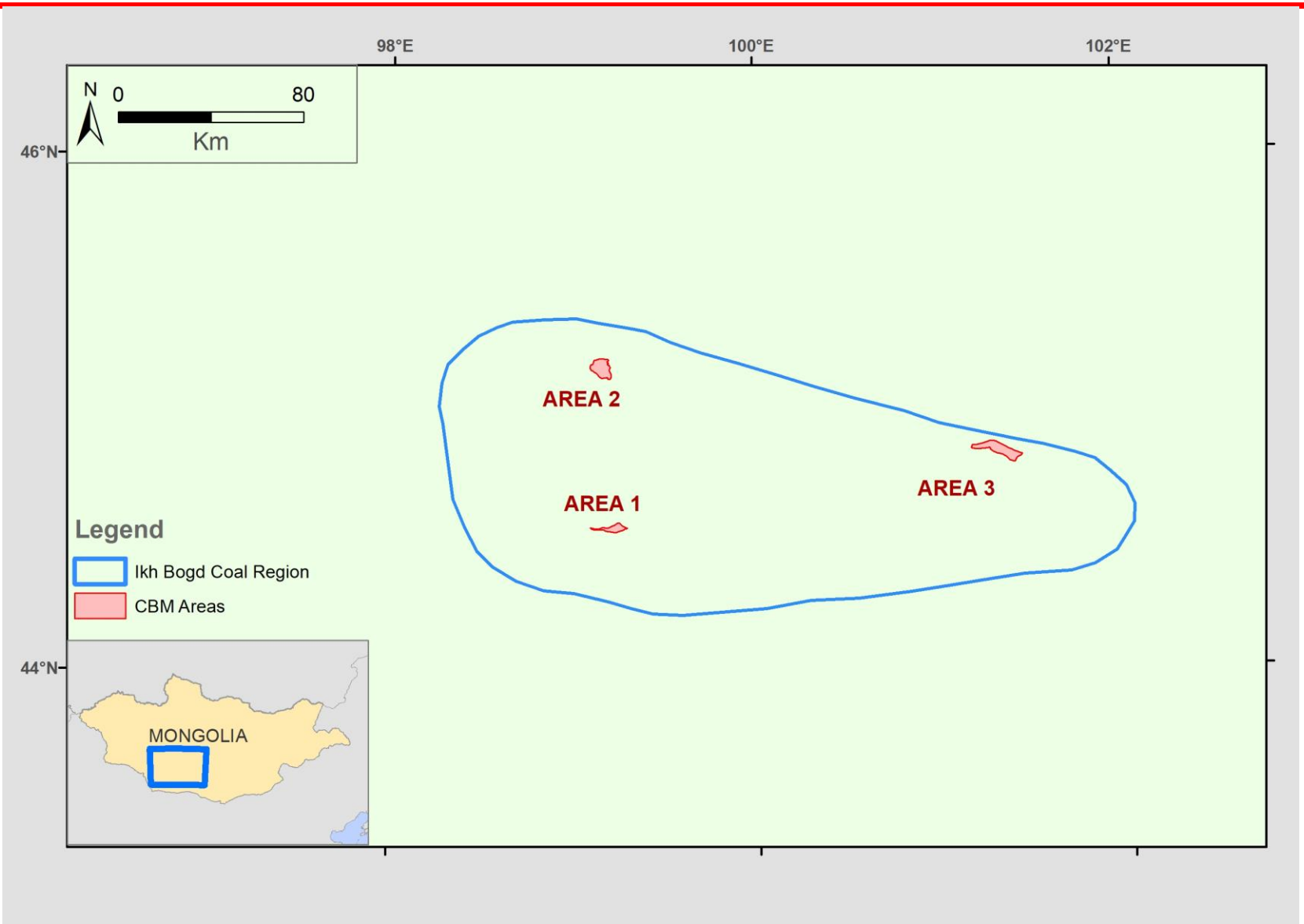
# Review of Area Selection




## South Khangai

- 3 Areas assessed
- Range in size from 38 to 256 km$^2$
- Areas range in rank from subbituminous A to C

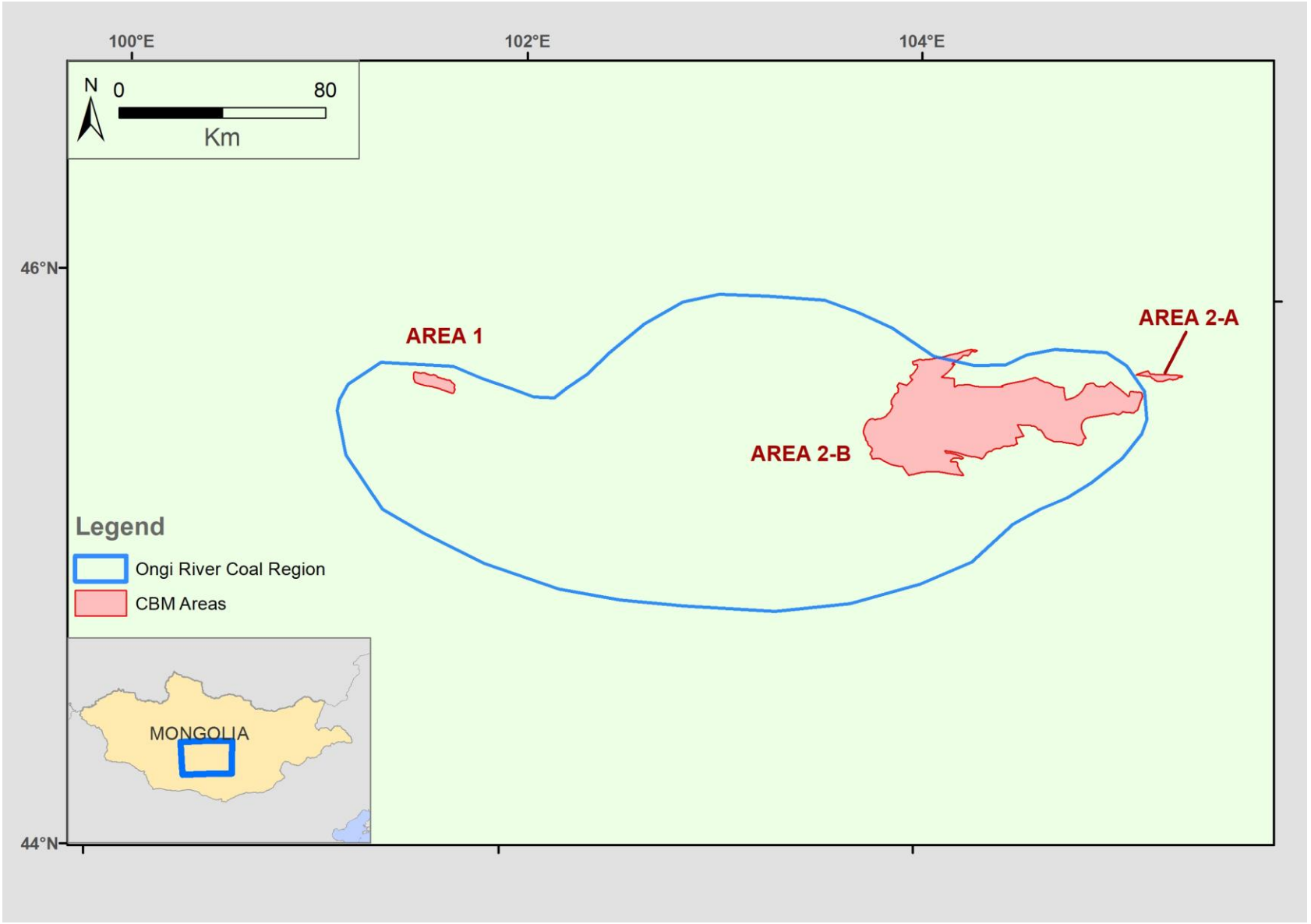
# Review of Area Selection




## Ikh Bogd

- 3 Areas assessed
- Range in size from 26 to 72 $km^2$
- Areas range in rank from high volatile bituminous B-A

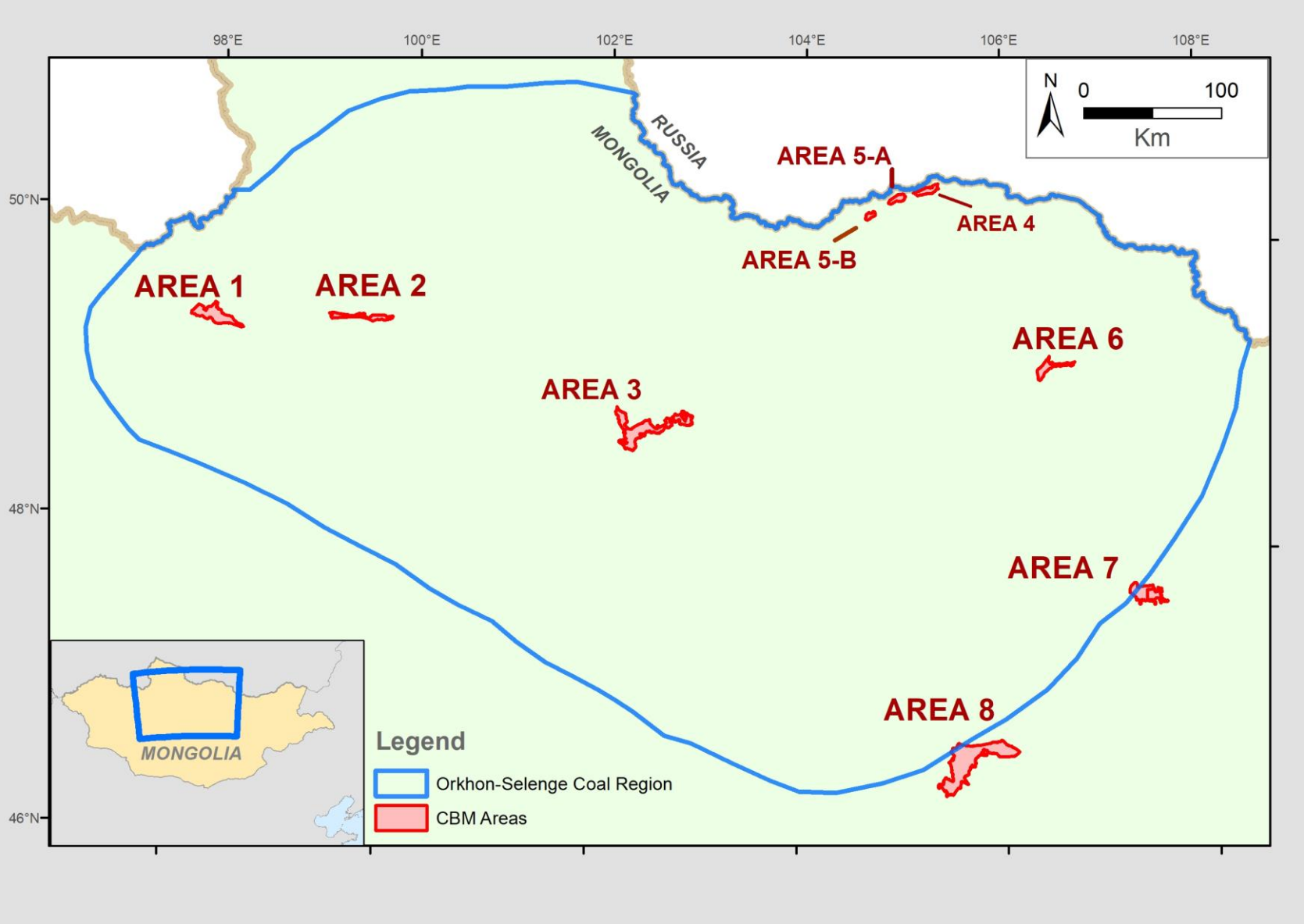
# Review of Area Selection




## Ongi River

- 2 Areas assessed
- Range in size from 30 to 2,518 km$^2$
- Areas range in rank from subbituminous C-B

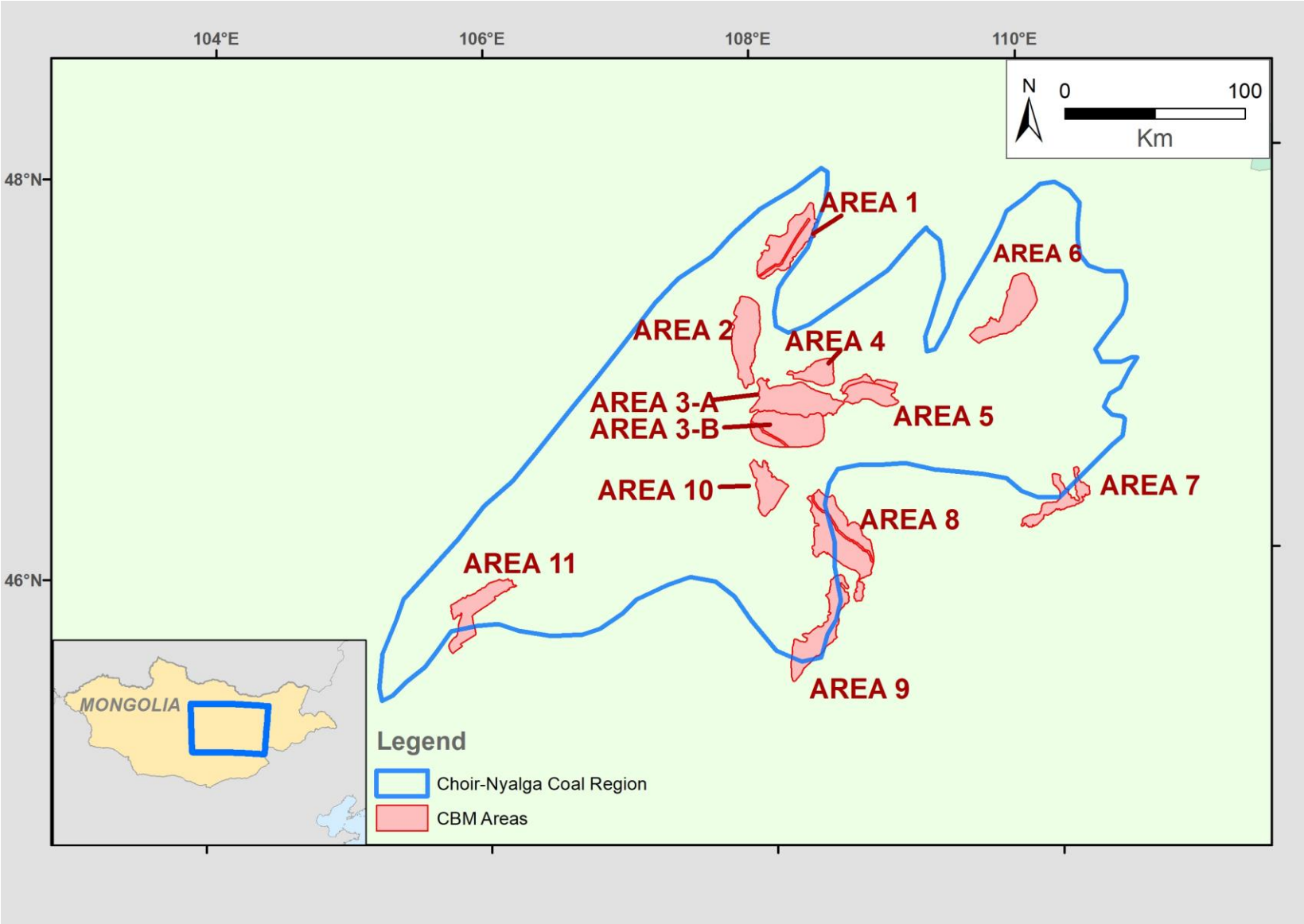
# Review of Area Selection




## Orkhon - Selenge

- 8 Areas assessed
- Range in size from 25 to 742 km$^2$
- Areas range in rank from subbituminous C to high volatile bituminous A

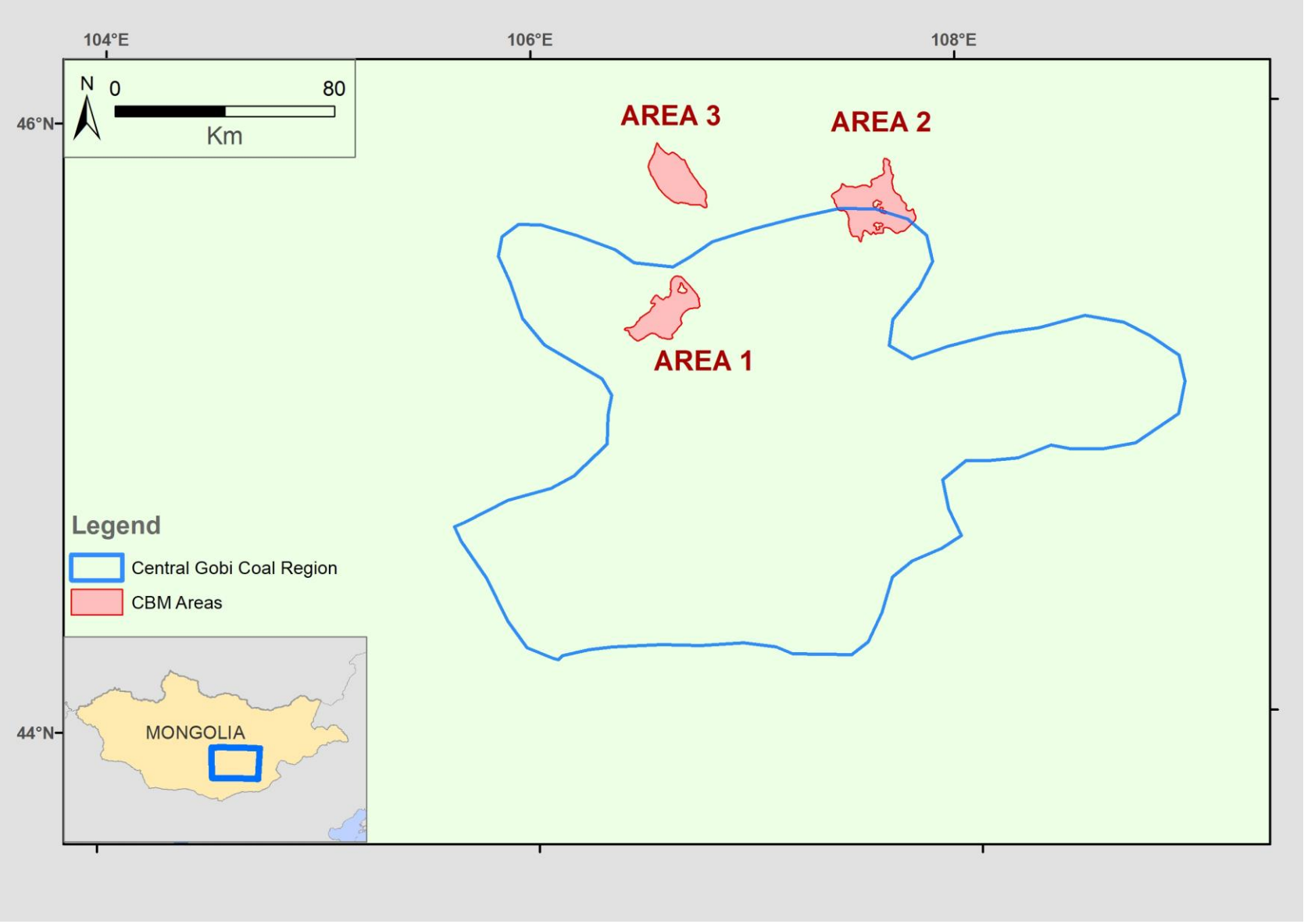
# Review of Area Selection




## Choir - Nyalga

- 11 Areas assessed
- Range in size from 224 to 990 km$^2$
- Areas range in rank from lignite to subbituminous A

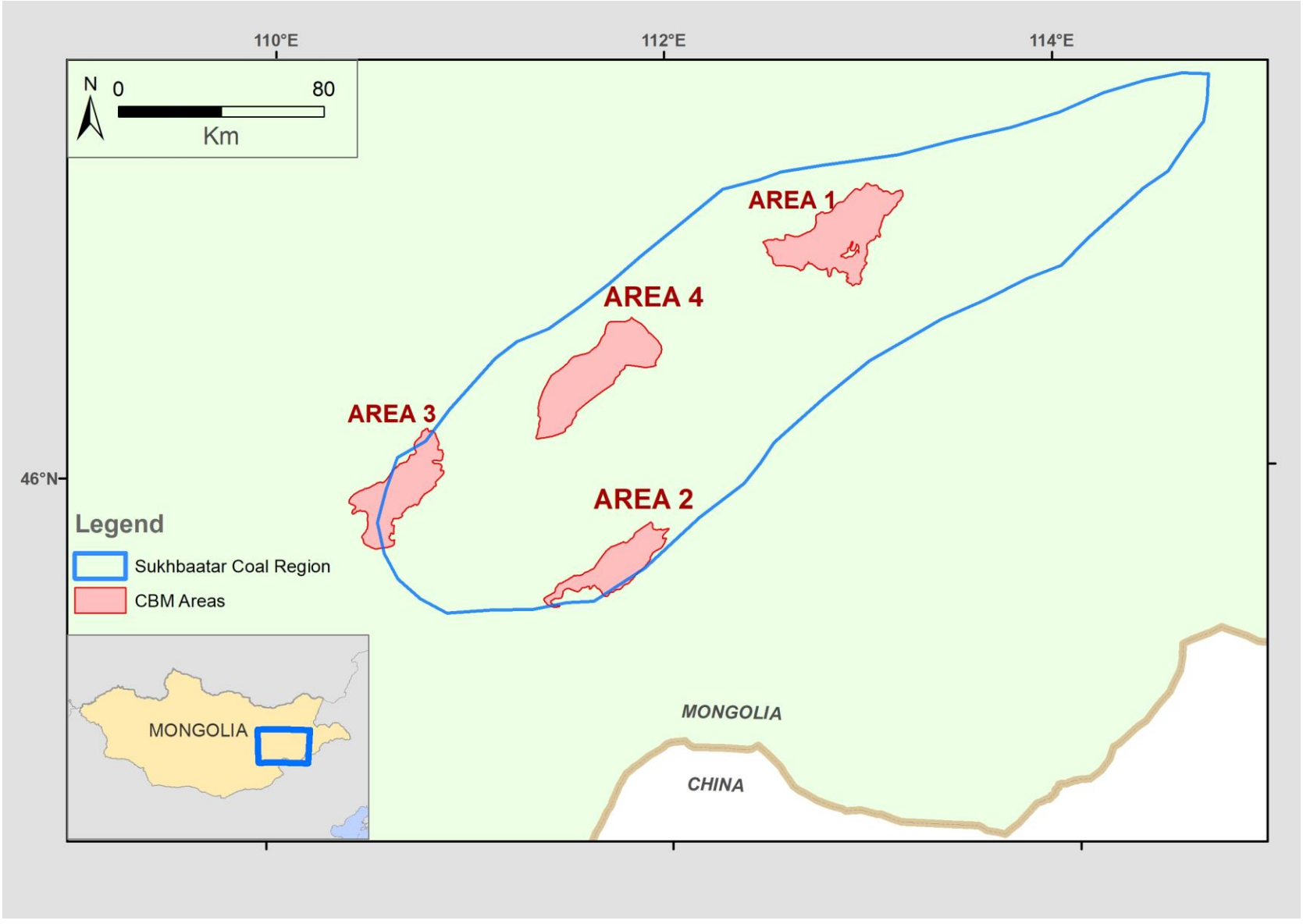
# Review of Area Selection




## Central Gobi

- 3 Areas assessed
- Range in size from 267 to 427 $km^2$
- Areas are lignite in rank

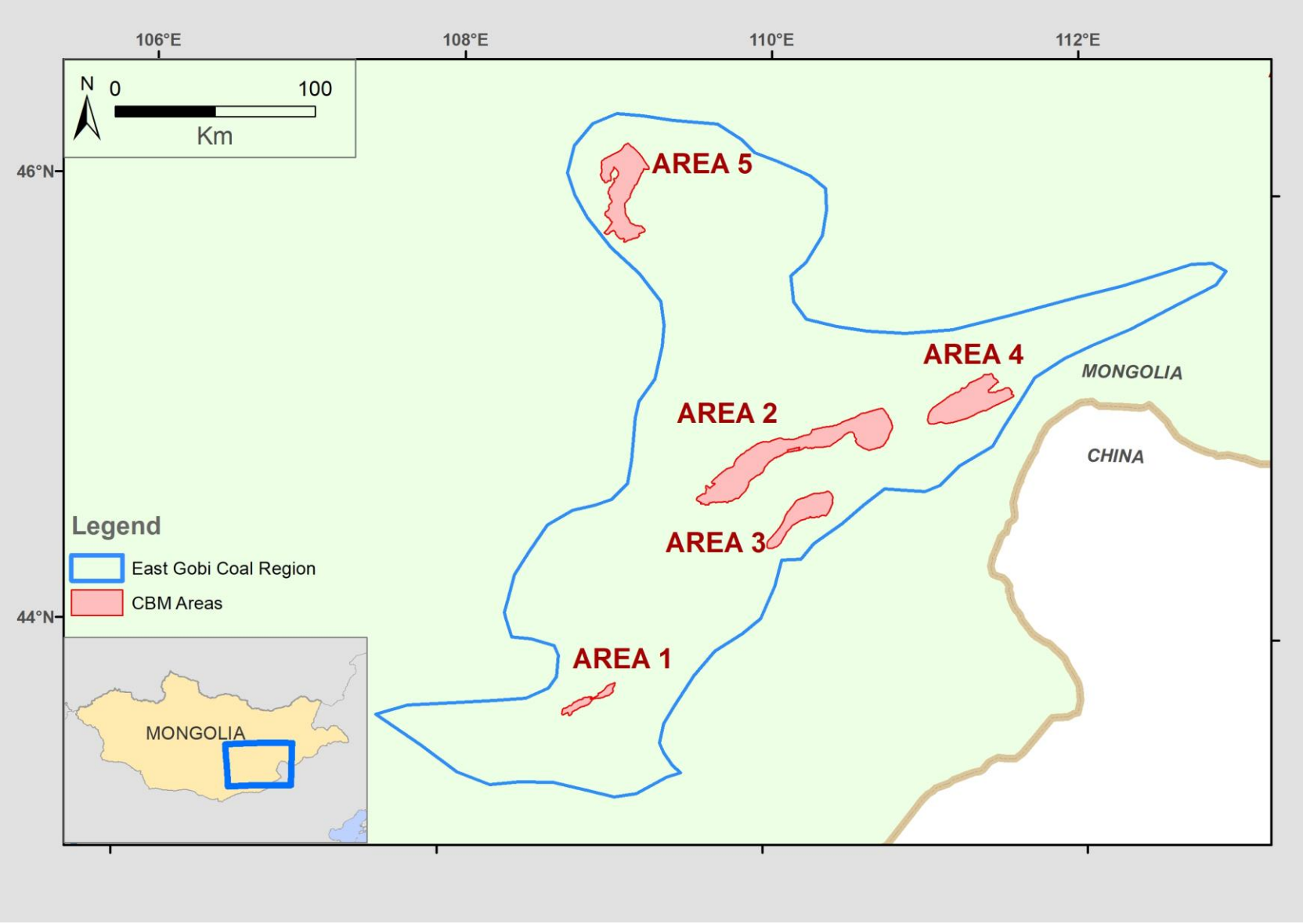
# Review of Area Selection




## Sukhbaatar

- 4 Areas assessed
- Range in size from 488 to 935 $km^2$
- Areas range in rank from lignite to subbituminous A

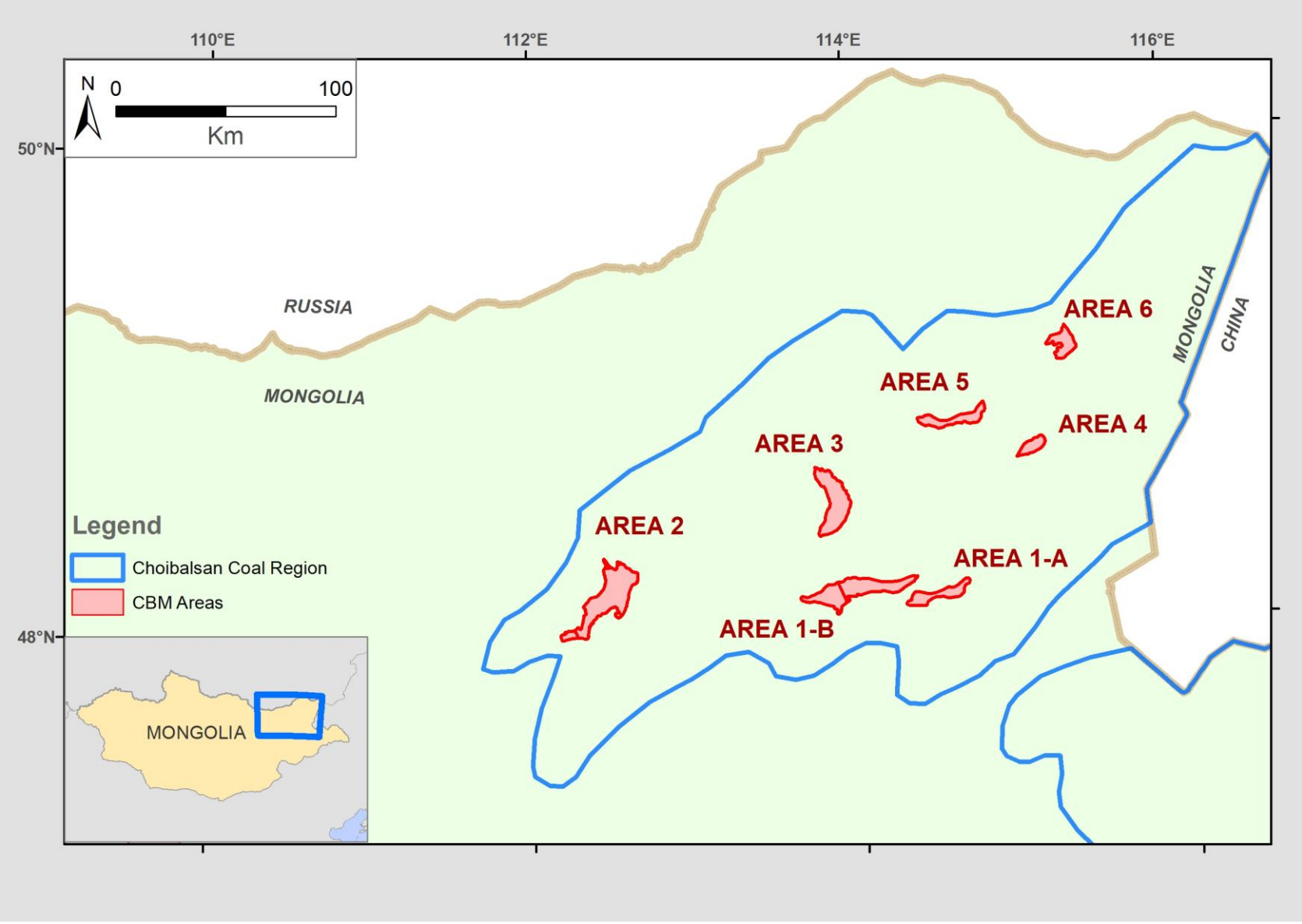
# Review of Area Selection




## East Gobi

- 5 Areas assessed
- Range in size from 89 to 1,142 $km^2$
- Areas range in rank from lignite to medium vol bituminous

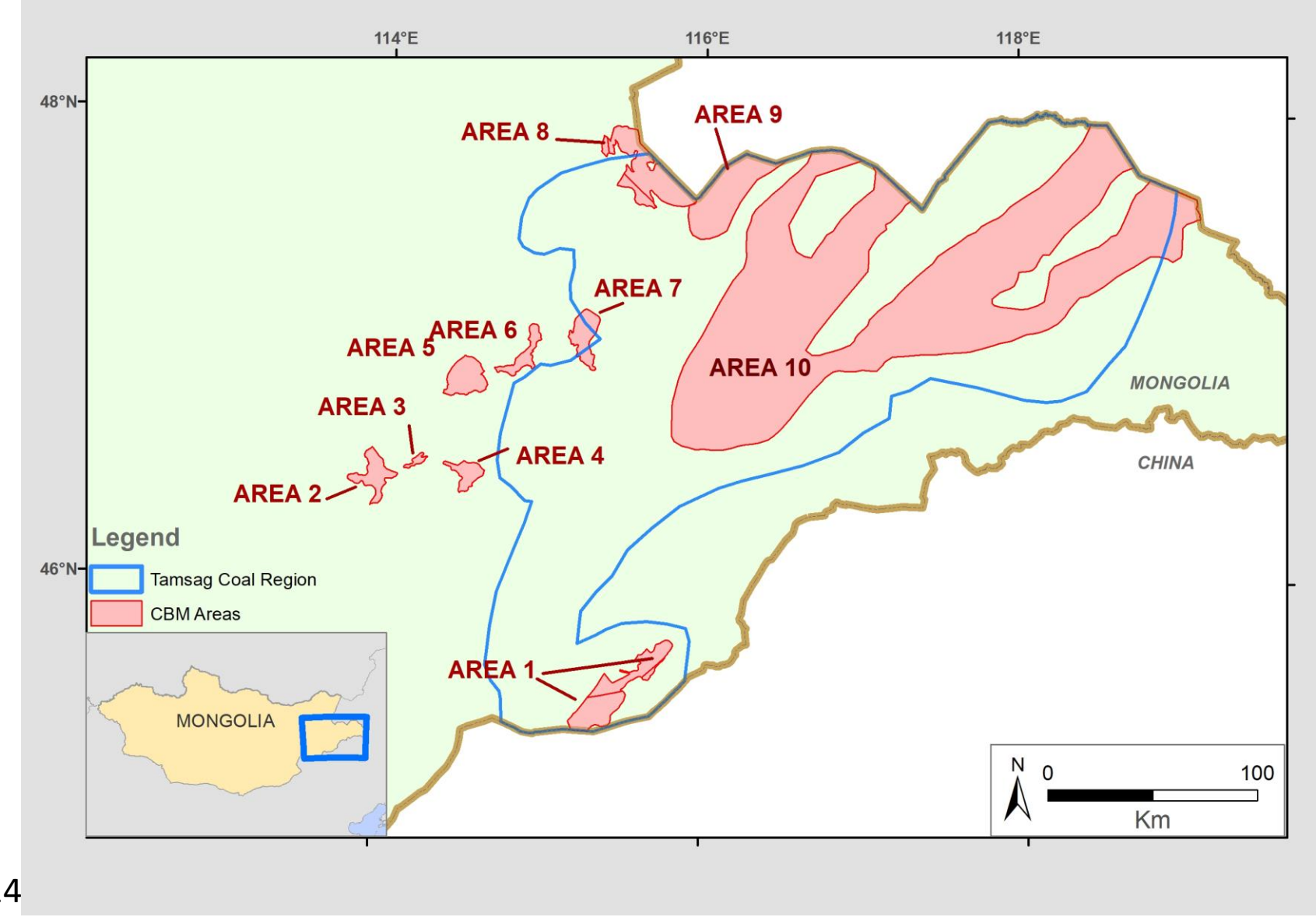
# Review of Area Selection




## Choibalsan

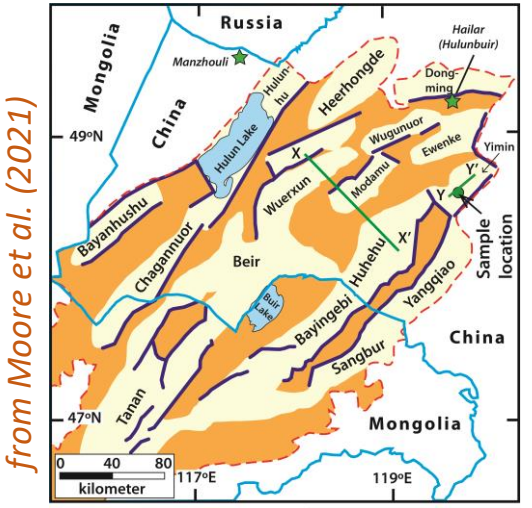
- 6 Areas assessed
- Range in size from 60 to 321 km$^2$
- Areas are lignite in rank

# Review of Area Selection




## Tamtsag

- 10 Areas assessed
- Range in size from 29 to 14,363 km$^2$
- Areas range in rank from lignite to subbituminous C




from Moore et al. (2021)

# Data Types and Limitations

1. **Confidential coal mine data**
2. **Confidential desorption data**
3. **Publically available company reports**
4. **Publically available published papers and reports**
5. **Publically available university theses**

# Data Types and Limitations

1. Mongolian coal-bearing regions are geographically quite extensive but the data tends to be restricted to the immediate area of existing mines.

2. Most of the coal seams in Mongolia do not outcrop and thus are not easily mapped, although the formations they occur within are often correlated in the subsurface for large distances.

3. The structural geology of Mongolia is highly complex and understudied. Coal-bearing formations assumed to occur over large distances may not. Seismic lines, gravity or magnetics were not examined in this study and thus formational continuity is uncertain.

4. The rank of the coal, which is fundamental in extrapolating gas content, is unknown in areas away from mines and thus inferred lateral and vertical changes have a high degree of uncertainty.

5. The veracity of the coal quality data can not always be evaluated and thus is taken at face value. No raw, laboratory data were sighted or examined in this study.

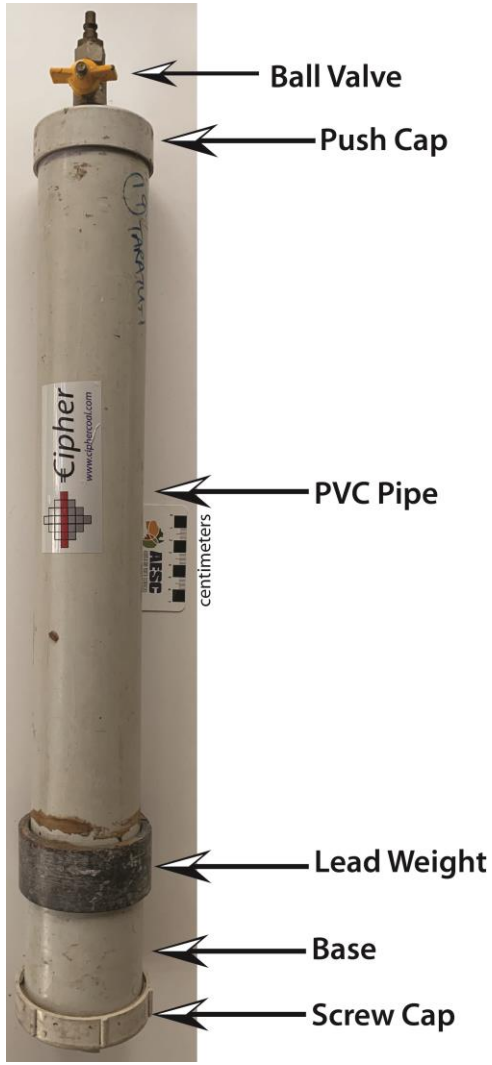
6. Only a few adsorption results have been reported and none of them have backing, corroborating information on their testing conditions.

7. No 'raw' laboratory data was sighted and examined for gas content (i.e. desorption analysis).

8. Some samples that were collected in the field, away from fresh mine faces, may be weathered and thus unreliable.

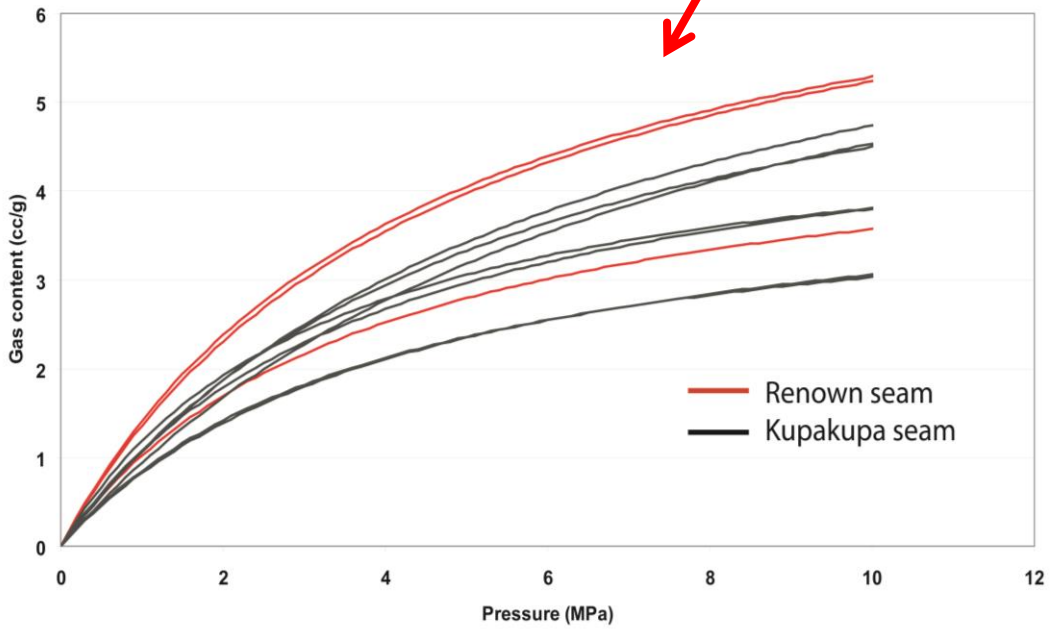
# Key Input Parameters

**The best data for estimating CBM reservoir properties is gas DESORPTION & ADSORPTION**




from: Moore (2012)

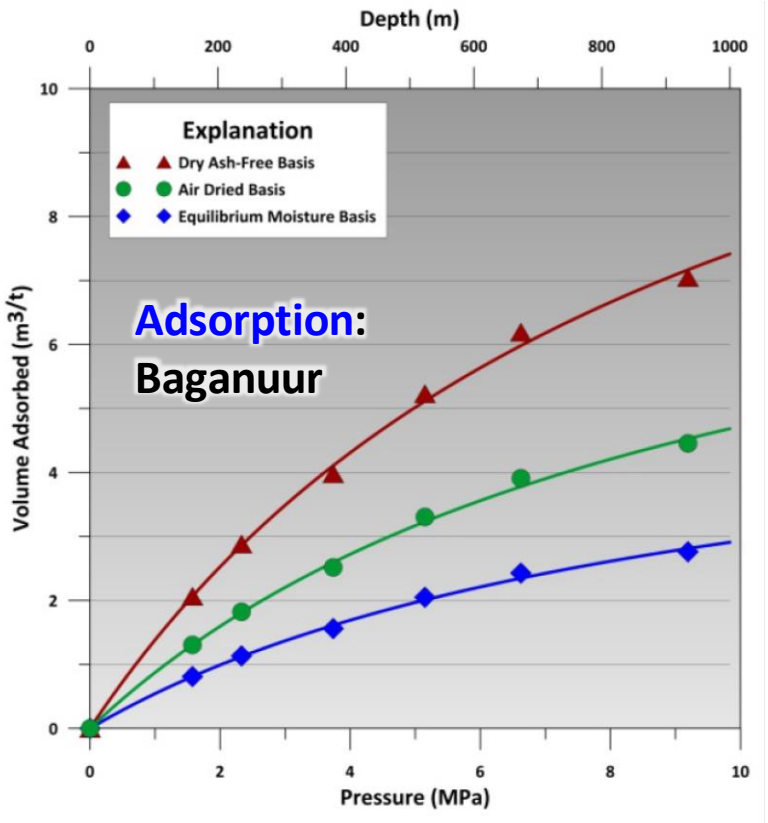
*Field measurement-drill site (ACTUAL gas)*



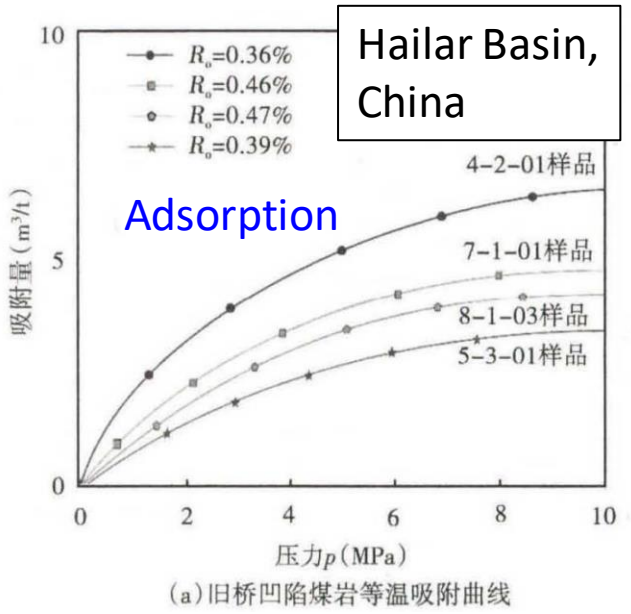

*Laboratory measurement (POTENTIAL gas)*

# Key Input Parameters

## Analogues for Adsorption and Desorption must be used – EXAMPLES:




*from: MNEC (2014)*




*from: Huangfu et al. (2016)*

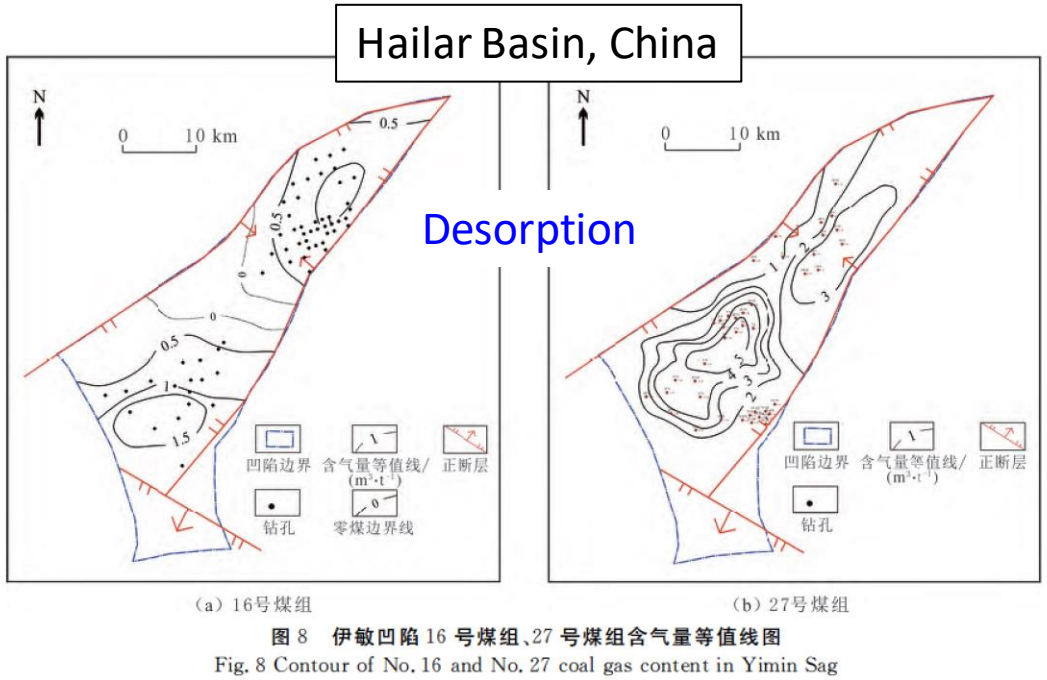



图 8 伊敏凹陷 16 号煤组、27 号煤组含气量等值线图

Fig. 8 Contour of No. 16 and No. 27 coal gas content in Yimin Sag

*from: Li et al. (2019)*

# Key Input Parameters

Input and evaluation parameters

| Parameter/Assessment Area | | 10 | Comments |
|---|---|---|---|
| Age | | Middle Jurassic | |
| Formation | | Orgilokhbulag | |
| Depth (m) | | 50-500 | Based on assumed watertable depth and possible deepest coal deposits |
| Surface Area (km²) | Low | 118.5 | 50% of high case |
| | Base | 213.2 | 90% of high case |
| | High | 236.9 | Area on the map |
| Net Coal Thickness (m) | Low | 15.2 | 40% of base case |
| | Base | 38.0 | Area 10 is small; coal thickness is likely much thinner compered with other NS deposits. |
| | High | 41.8 | 10% higher than base case |
| Density (g/cm³) | | 1.43 | Based on average ash of 13% for bituminous coal |
| Desorbed Gas Volume (m³/ton) ar | Low | 0.5 | Based on available tabulated data |
| | Base | 5 | Based on available tabulated data |
| | High | 12 | Based on available tabulated data |
| Play Type | | Thermogenic | Based on rank of coal |
| Vitrinite Reflectance (%) | | 0.74-0.78 | Based on data listed in SGB04 |
| Heating Value (kcal/kg, daf) | | 7663-8079 | Based on data listed in SGB04 |
| Volatile Matter (%, ad) | | 30.88-32.31 | Based on data listed in SGB04 |
| Ash Yield (%, db) | | 10.13-17.61 | Based on data listed in SGB04 |
| Moisture (%, ad) | | 1.14-1.6 | Based on data listed in SGB04 |
| Estimated coal rank | | high vol B-A bit | Based on vitrinite reflectance, heating value and volatile matter |
| Estimated water table depth (m) | | 50 | Assumed |
| Analogues for Gas Content (if applicable) | | Parameters based on Jurassic age deposits in the Naryn Sukhait deposit; Sunrise and Sunset coal mine as well as the adsorption isotherm from for the Naryn Sukhait deposit in the MNEC (2014) report. | |

Background information

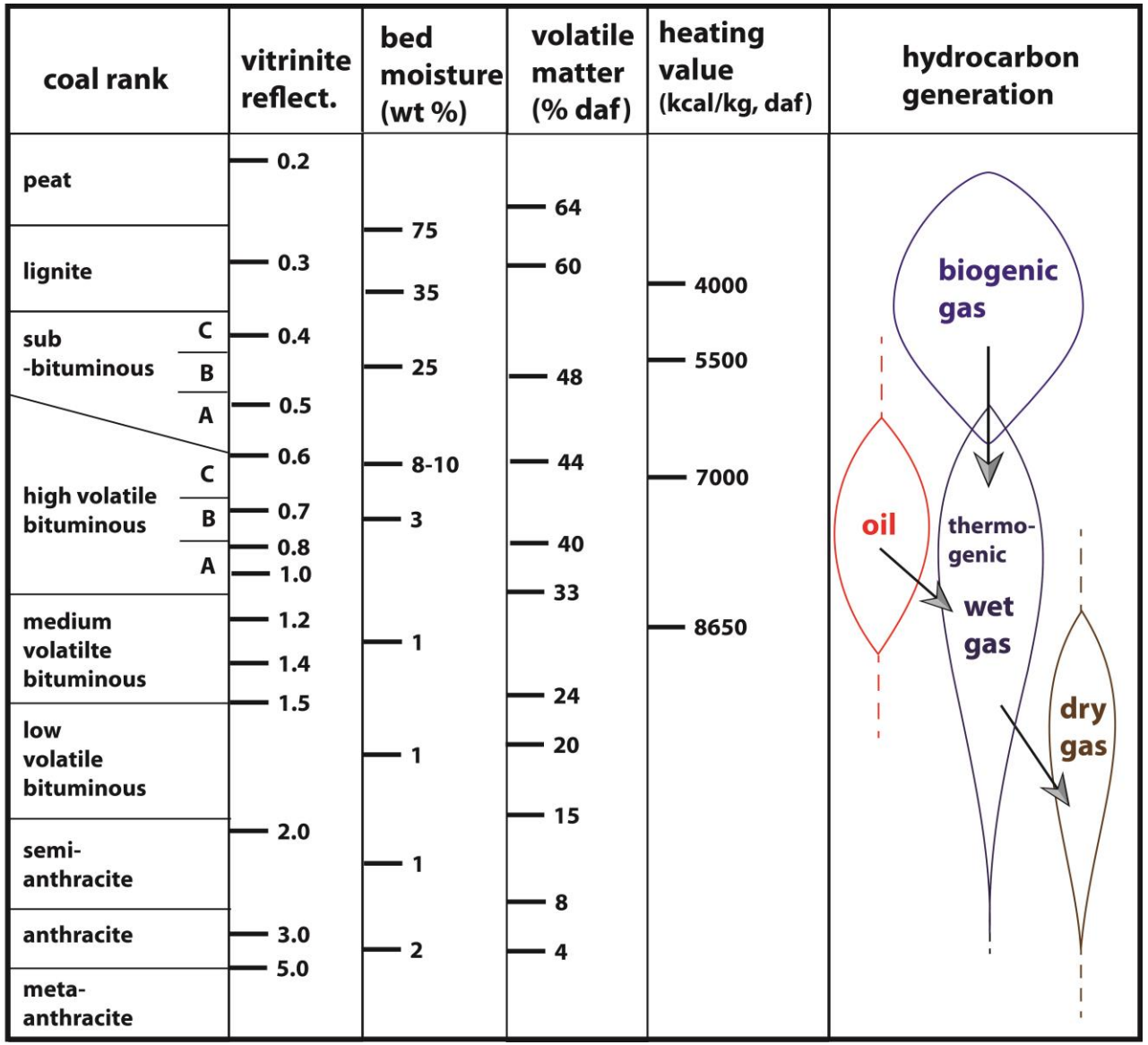
Important in estimating pressure

Input for probabilistic analysis

Estimated from Evaluation parameters

Evaluation parameters

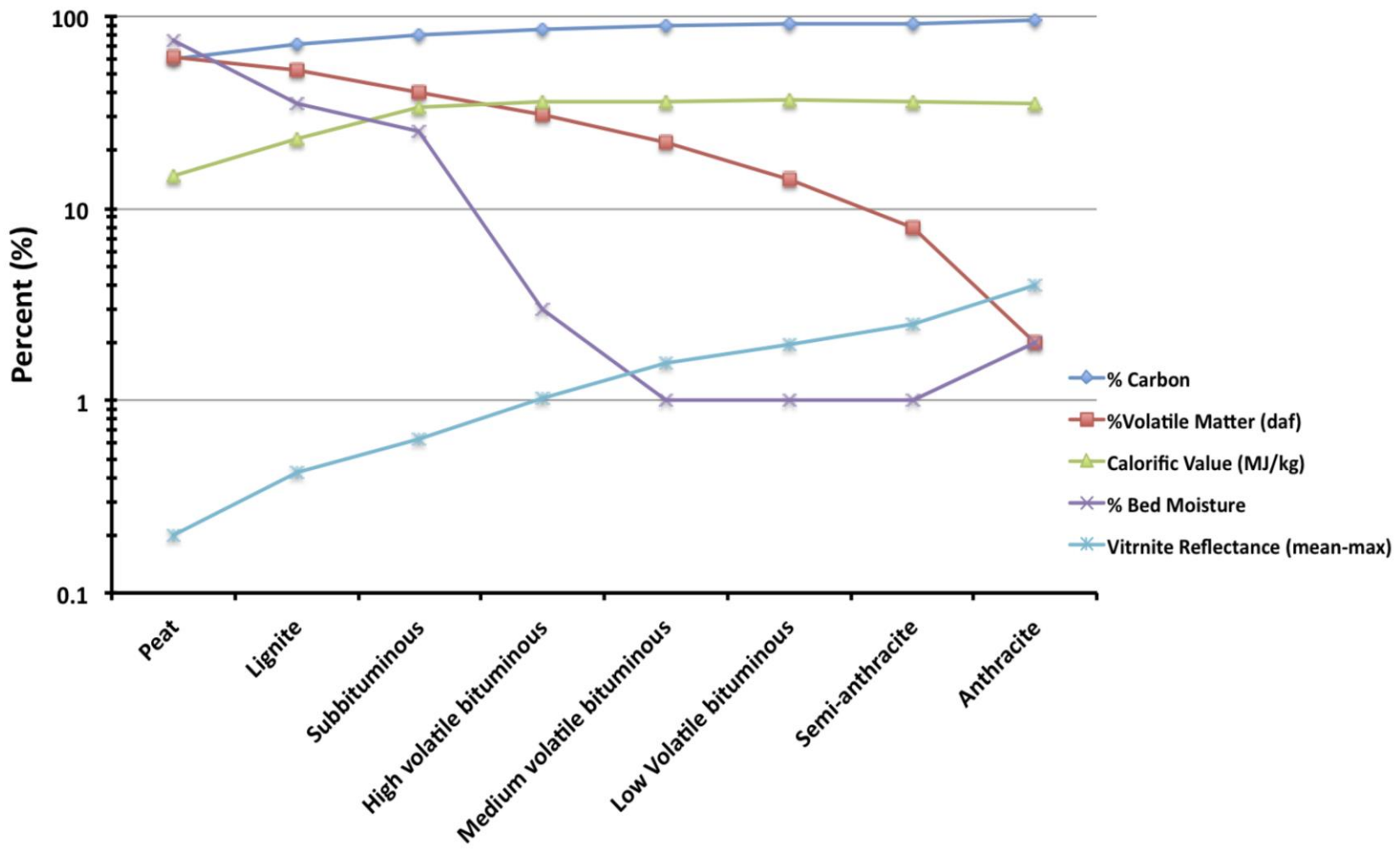
# Key Input Parameters




from: Moore (2012)

- In trying to apply an ANALOGUE to estimate gas content, at least some properties of the reservoir (i.e. coal bed) need to be established.
- Gas holding capacity and gas content is largely (though not solely) related to rank (i.e. level of thermal maturation of the organic material), and rank can be used to infer gas properties.
- More than one parameter should be used when estimating – or even measuring! - rank.
- The effect of coal type on 'rank' should not be underestimated.

# Key Input Parameters




- **Not all analyses are best at estimating rank**
- Vitrinite reflectance best overall (although can be suppressed)
- Volatile matter good, but affected by coal type
- Bed moisture good at low ranks, but hard to really measure accurately.

*from: Moore (2012)*

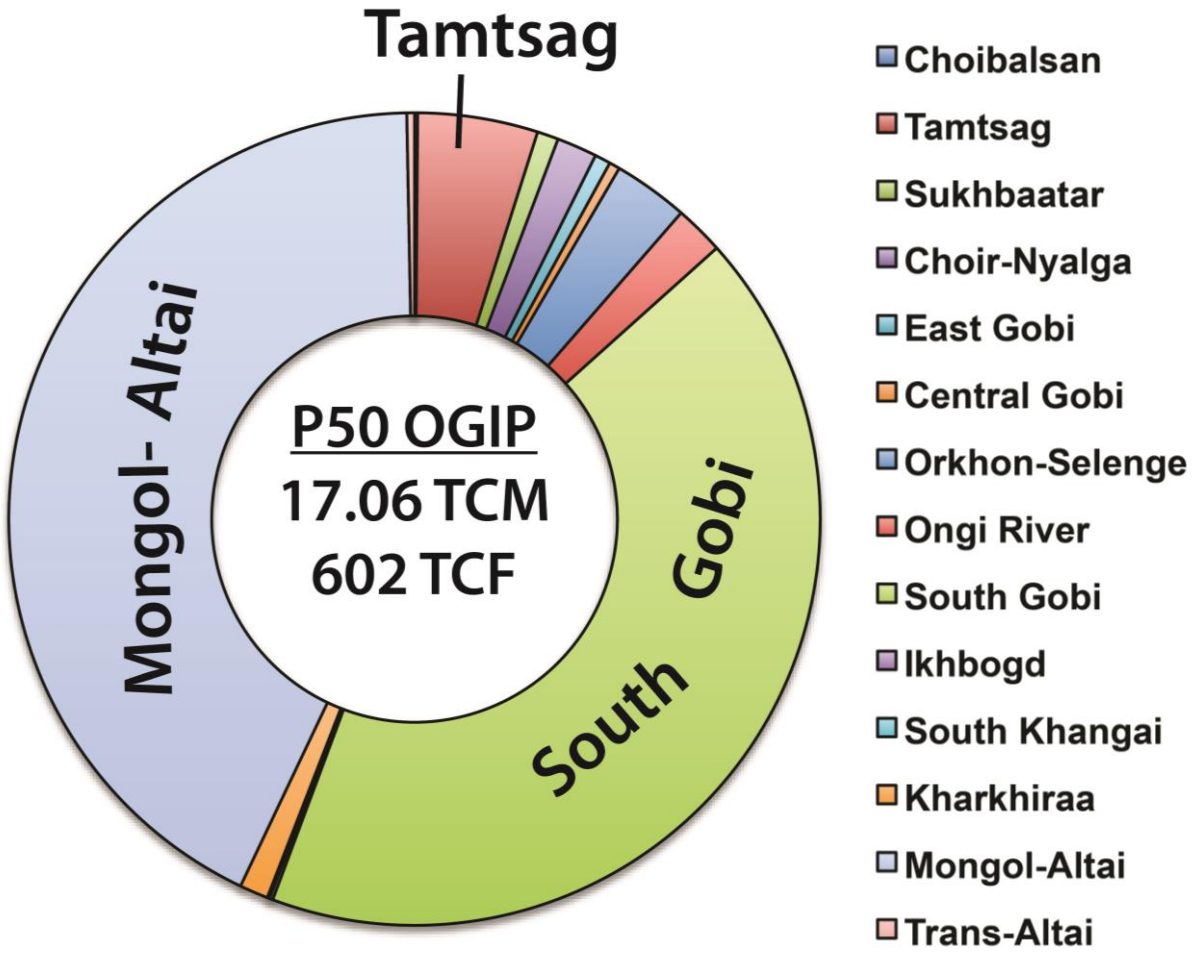
# RESULTS

*Photo by M.C. Friederich (2010) Area 2, South Gobi Region; Permian-age Delin Shan Formation.*

# Results of Assessment – All of Mongolia

## Original Gas In-place (BCM)

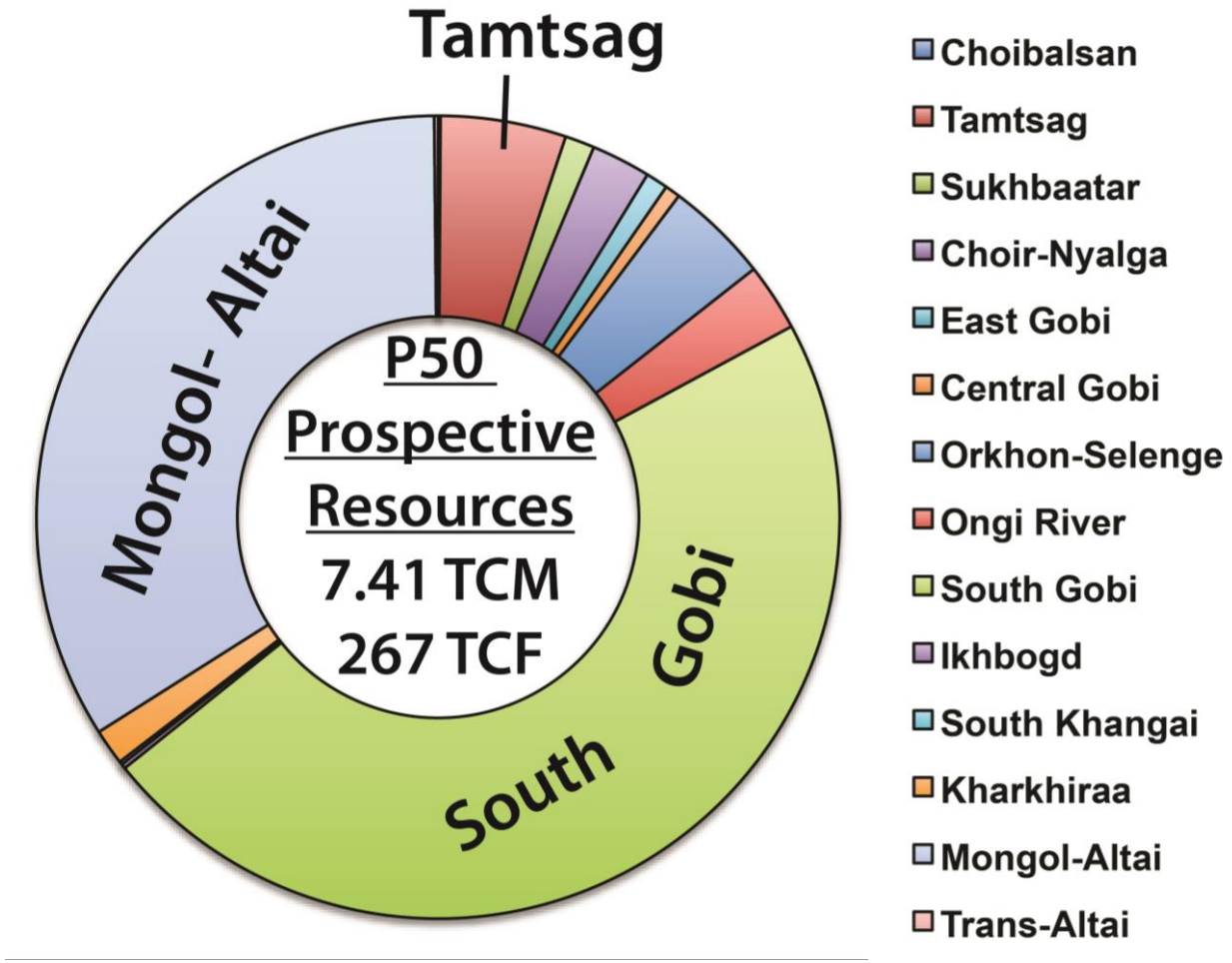
| Region | P90 | P50 | P10 |
|---|---|---|---|
| Choibalsan | 15 | 20 | 27 |
| Tamtsag | 364 | 790 | 1,696 |
| Sukhbaatar | 96 | 140 | 197 |
| Choir-Nyalga | 200 | 265 | 347 |
| East Gobi | 75 | 105 | 142 |
| Central Gobi | 48 | 70 | 98 |
| Orkhon-Selenge | 328 | 495 | 785 |
| Ongi River | 154 | 324 | 560 |
| South Gobi | 4,934 | 6,987 | 9,782 |
| Ikhbogd | 16 | 22 | 29 |
| South Khangai | 11 | 16 | 22 |
| Kharkhiraa | 135 | 189 | 256 |
| Mongol-Altai | 3,920 | 7,041 | 12,055 |
| Trans-Altai | 39 | 50 | 64 |
| All Areas | 12,967 | 17,061 | 22,599 |



# Results of Assessment – All of Mongolia

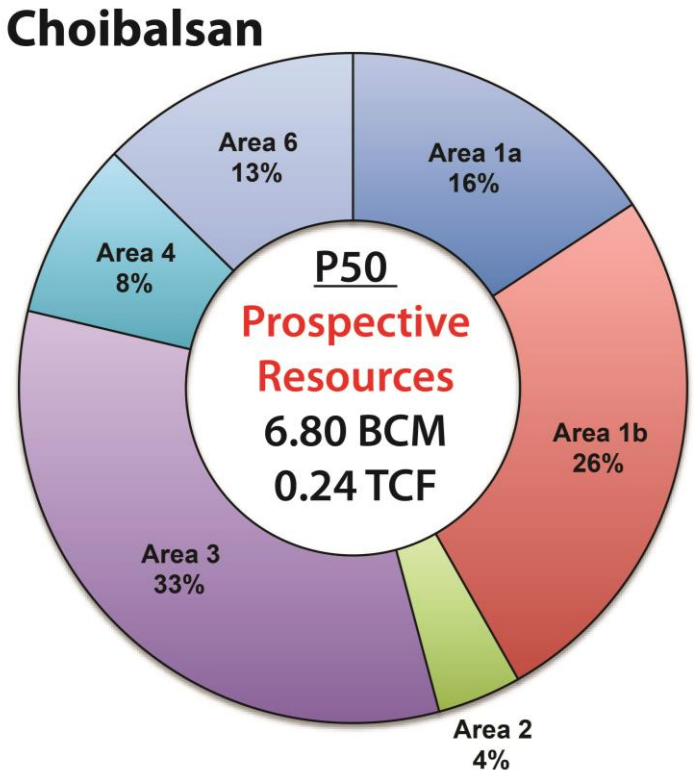
## Prospective Resources (BCM)

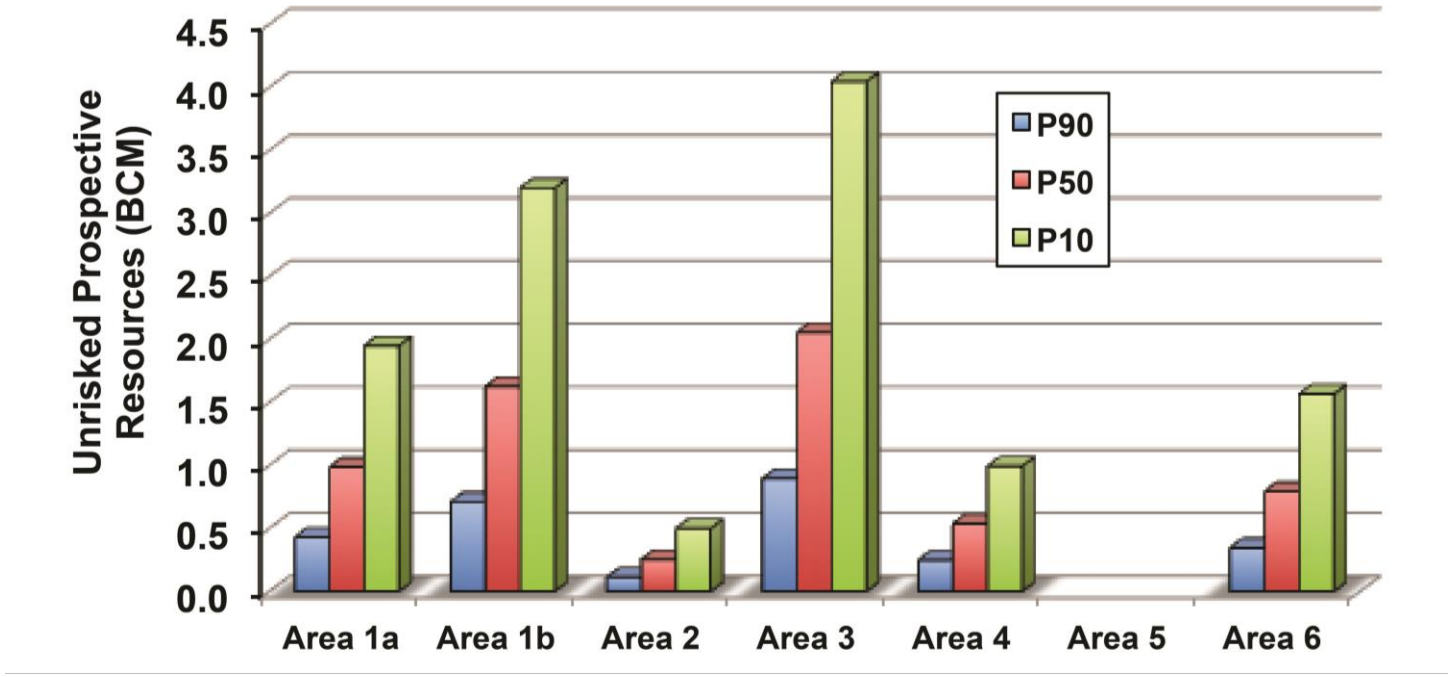
| Region | P90 | P50 | P10 |
|---|---|---|---|
| Choibalsan | 5 | 7 | 9 |
| Tamtsag | 170 | 364 | 762 |
| Sukhbaatar | 58 | 86 | 124 |
| Choir-Nyalga | 129 | 172 | 227 |
| East Gobi | 45 | 64 | 89 |
| Central Gobi | 28 | 44 | 62 |
| Orkhon-Selenge | 196 | 300 | 485 |
| Ongi River | 90 | 196 | 354 |
| South Gobi | 2,503 | 3,394 | 4,579 |
| Ikhbogd | 9 | 14 | 19 |
| South Khangai | 6 | 10 | 14 |
| Kharkhiraa | 74 | 104 | 144 |
| Mongol-Altai | 1,537 | 2,436 | 3,885 |
| Trans-Altai | 8 | 11 | 17 |
| All Areas | 5,982 | 7,408 | 9,230 |



# Results of Assessment - Choibalsan

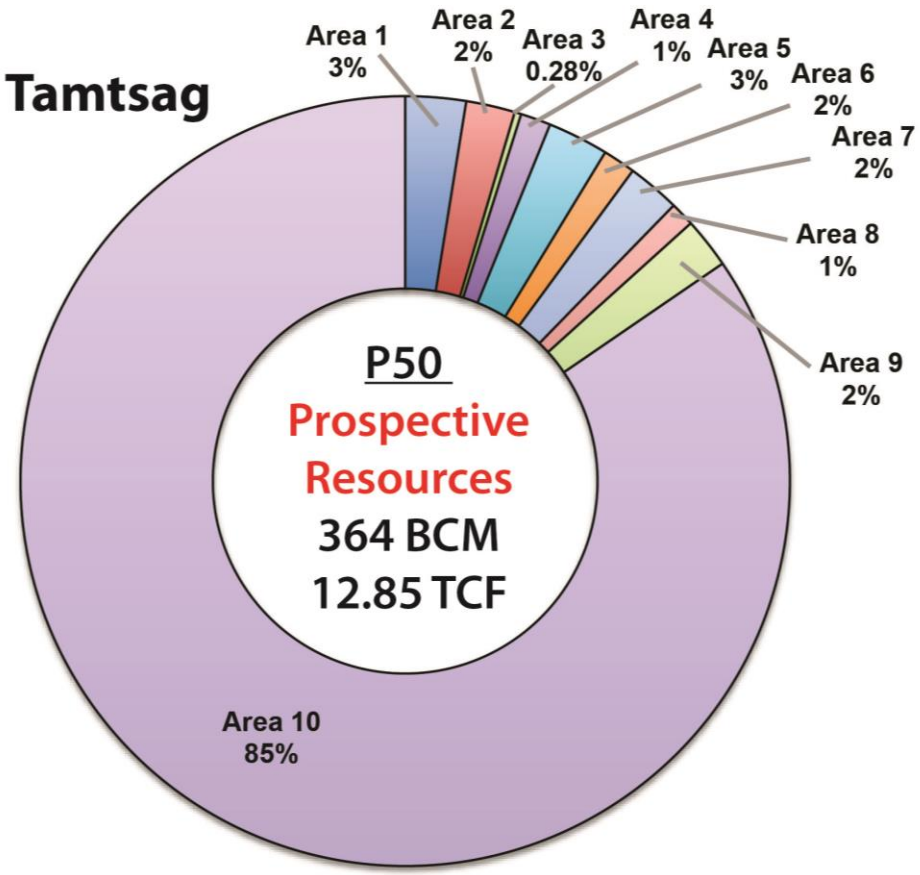
## Prospective Resources

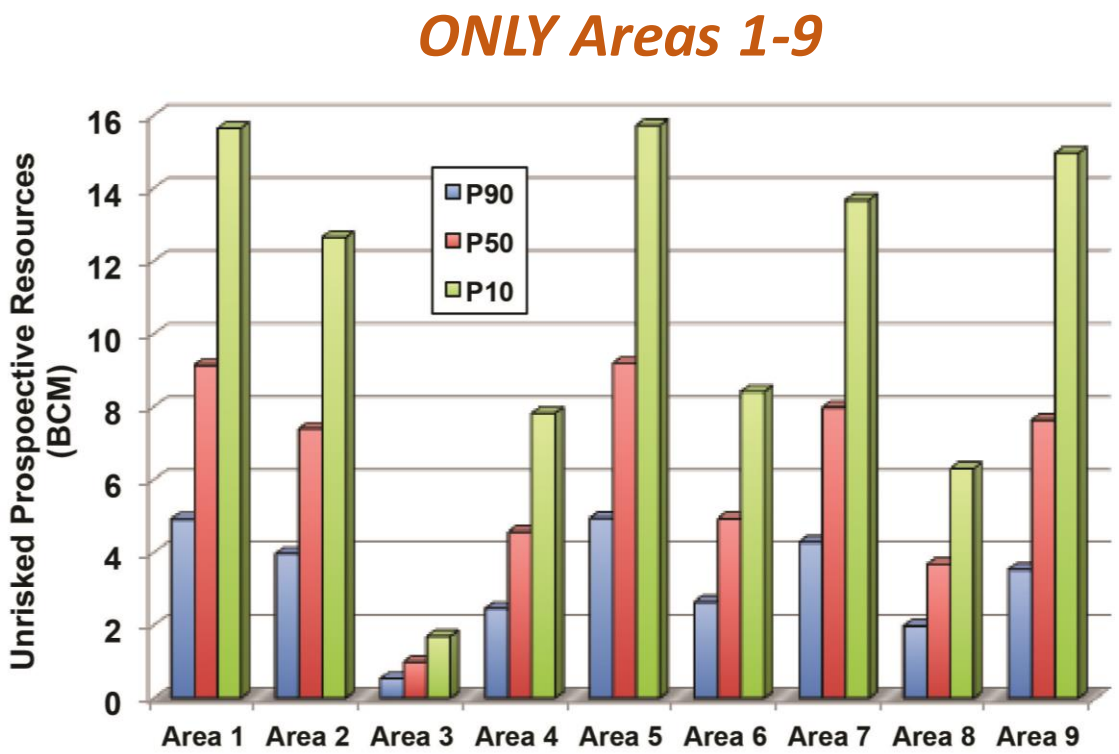


# Results of Assessment - Tamtsag

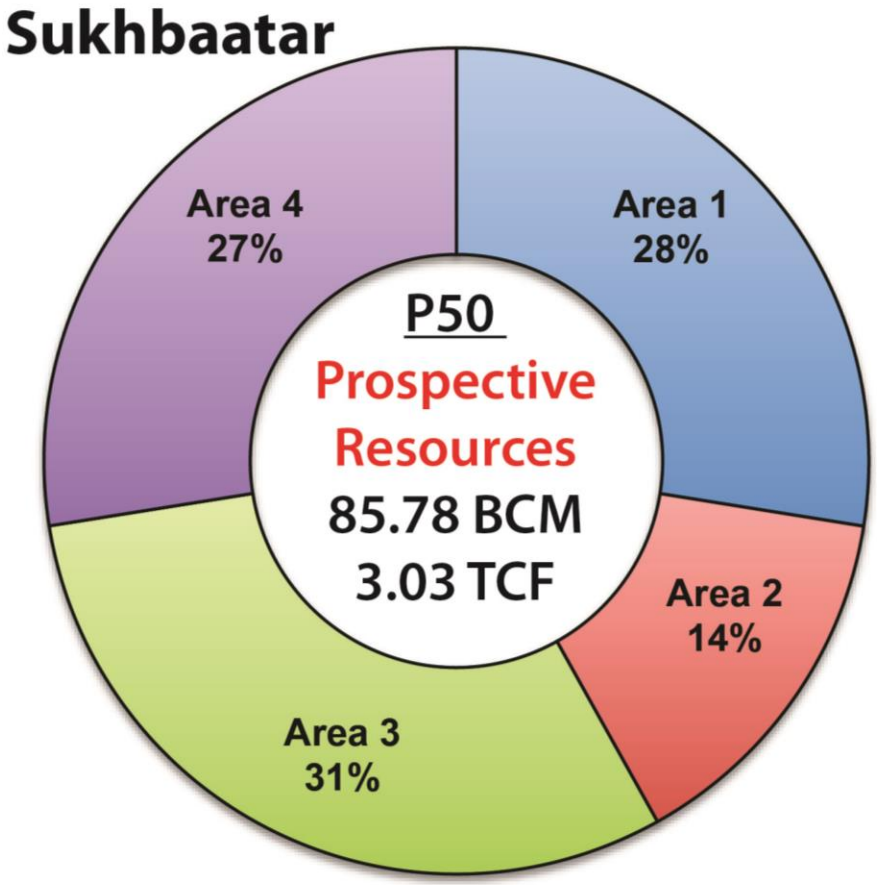
## Prospective Resources

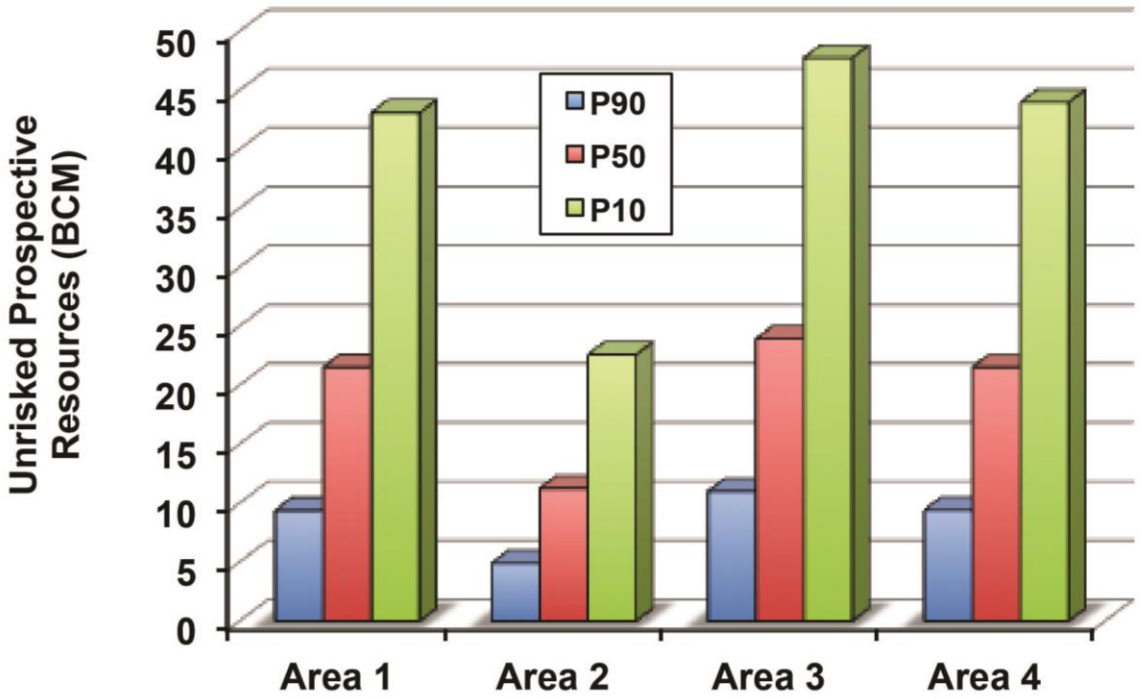


# Results of Assessment - Sukhbaatar

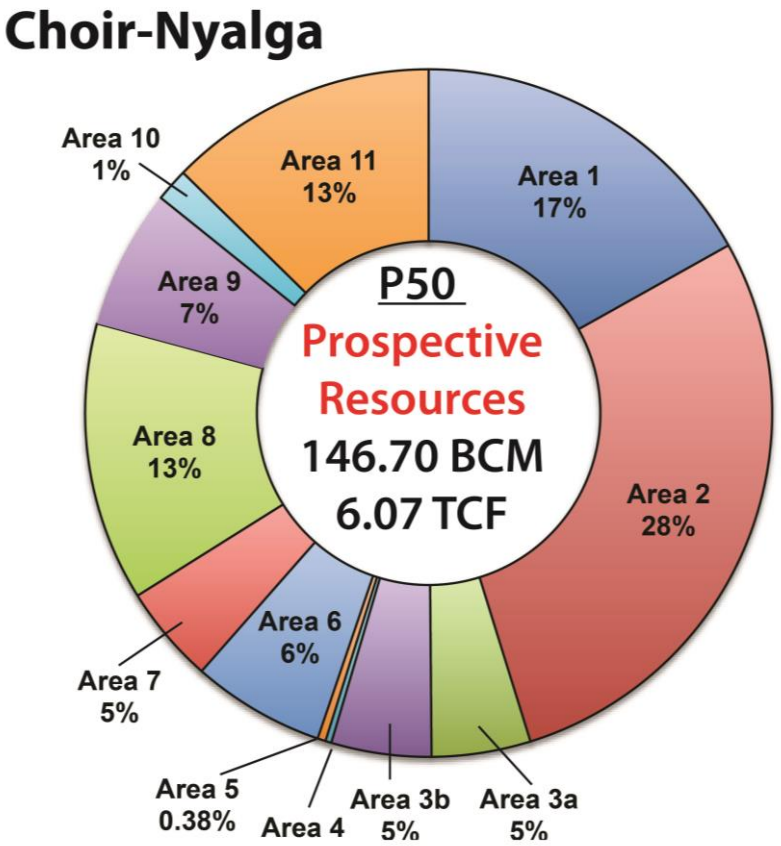
## Prospective Resources

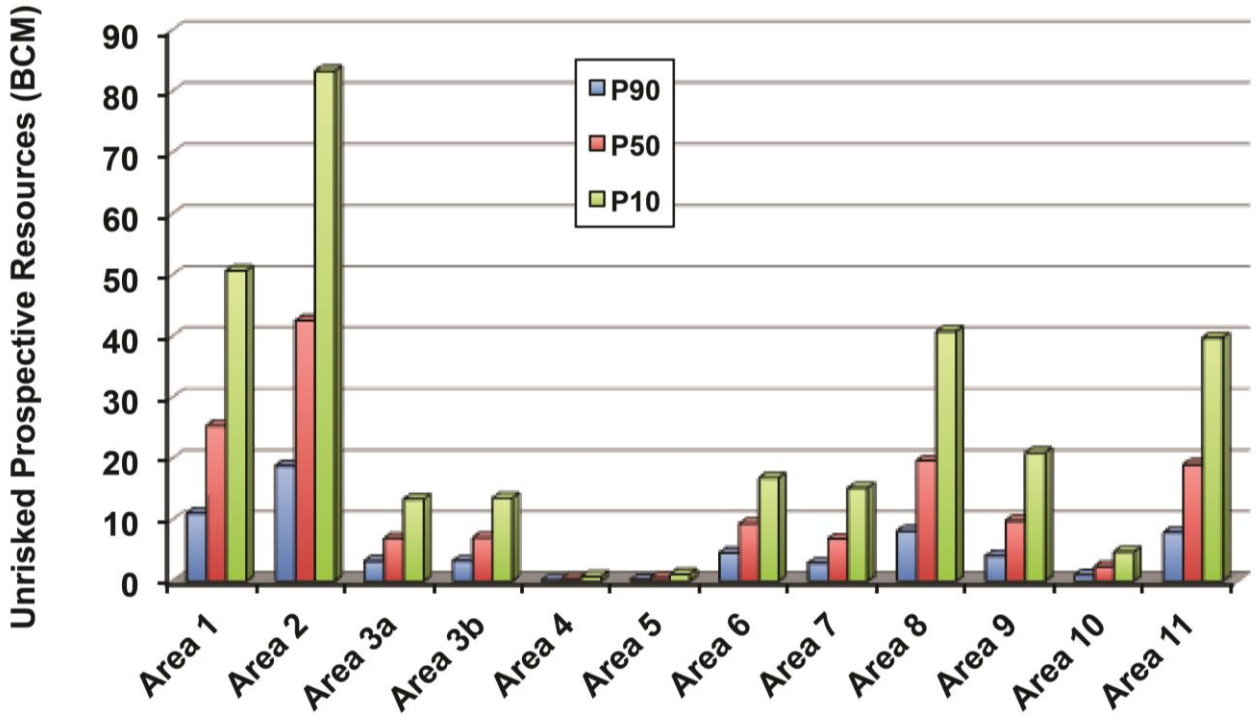


# Results of Assessment – Choir-Nyalga

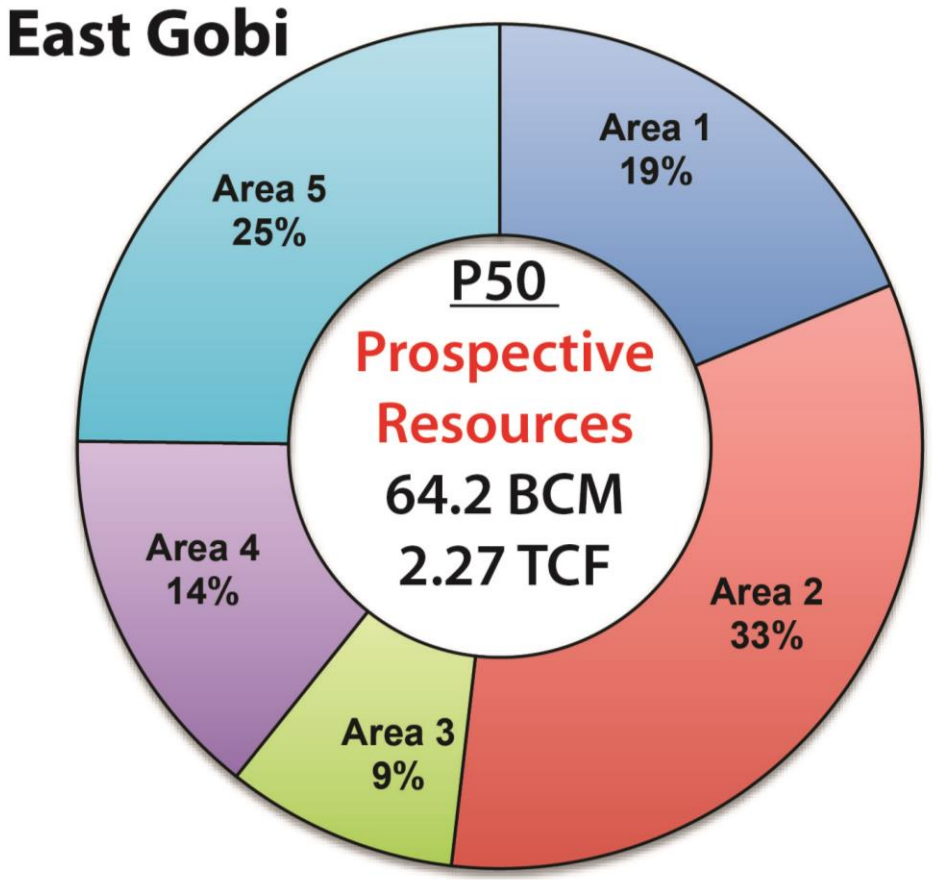
## Prospective Resources

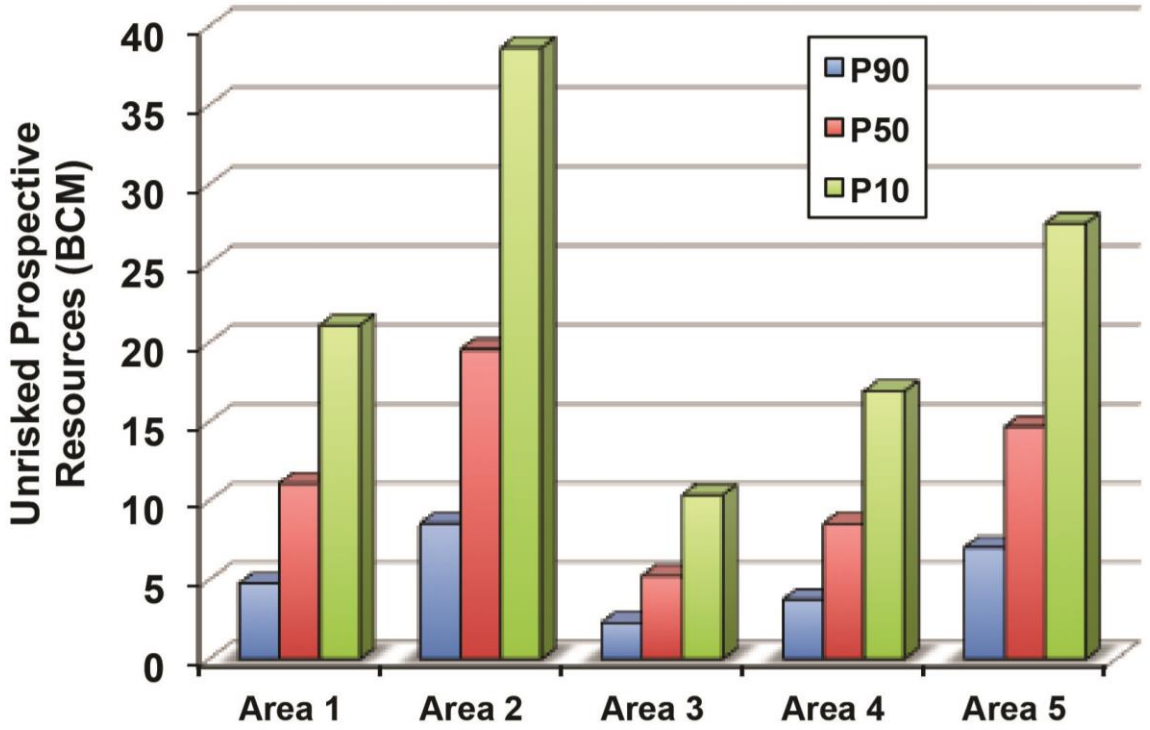


# Results of Assessment – East Gobi

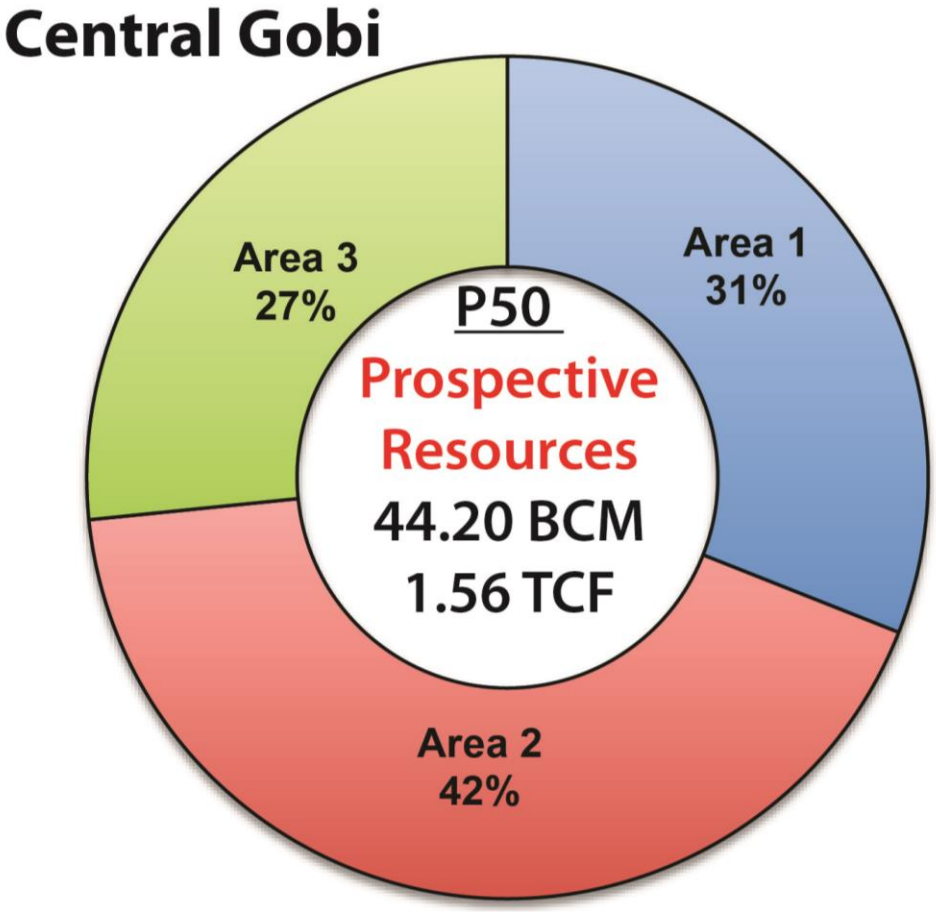
## Prospective Resources

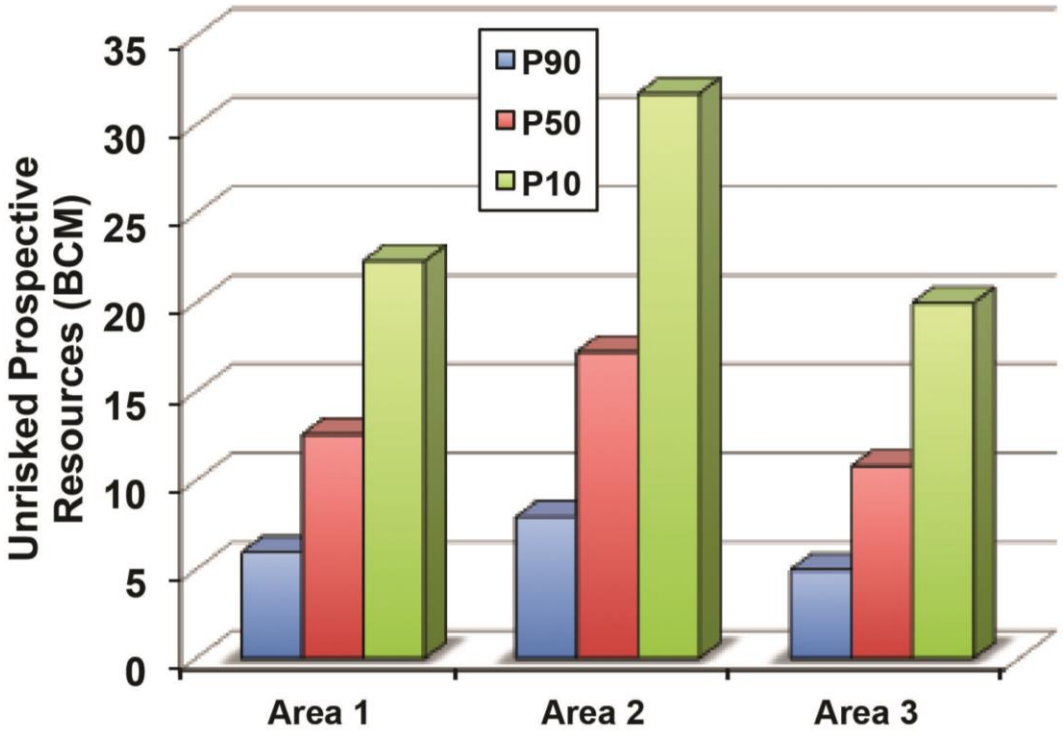


# Results of Assessment – Central Gobi

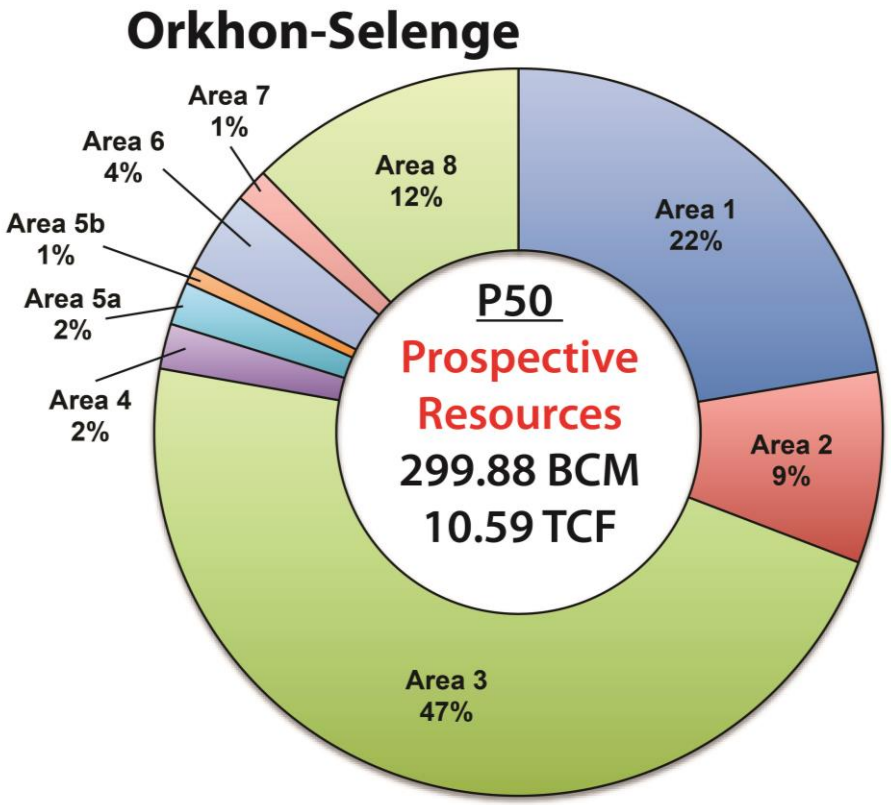
## Prospective Resources

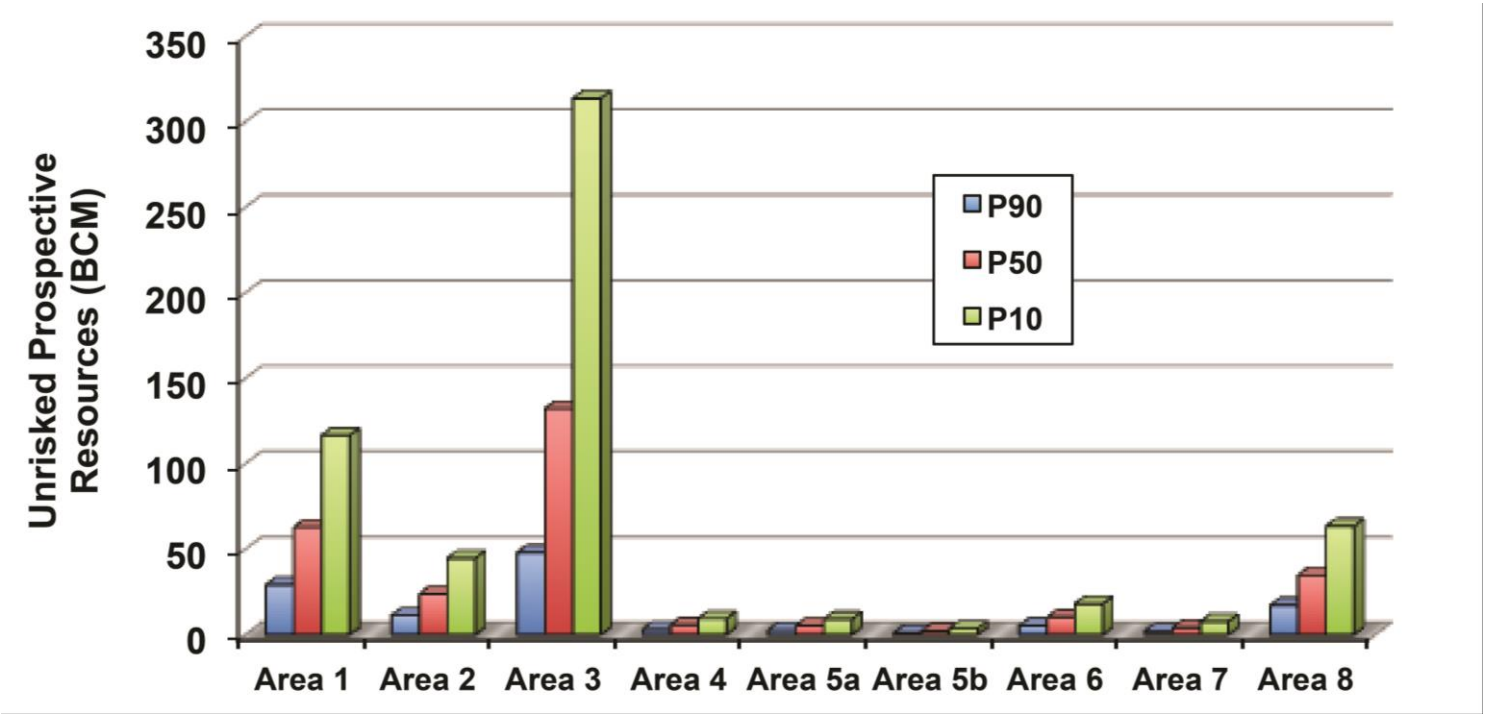


# Results of Assessment – Orkhon-Selenge

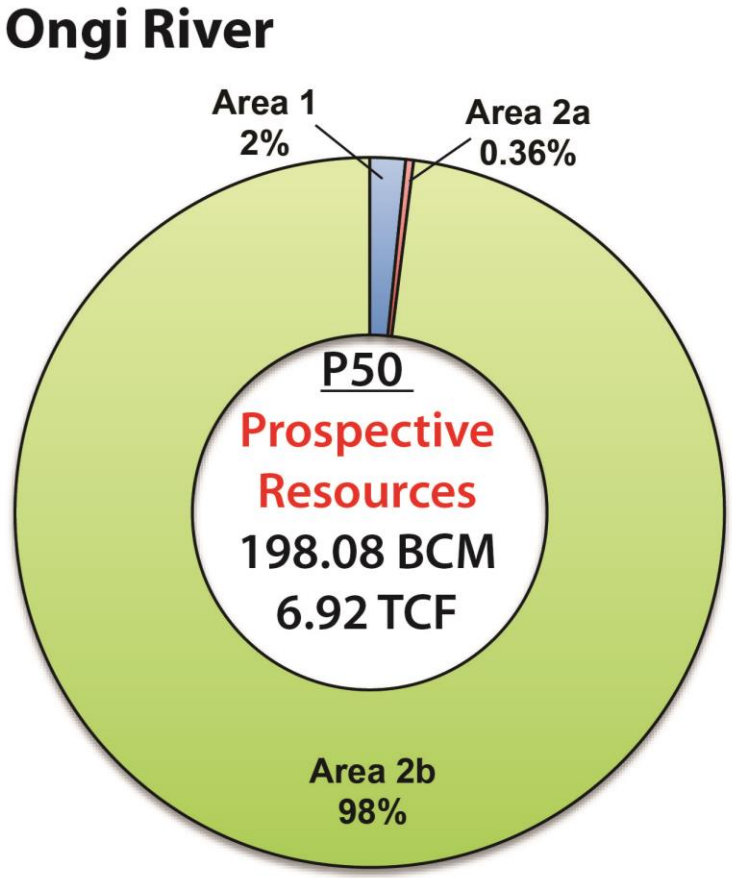
## Prospective Resources

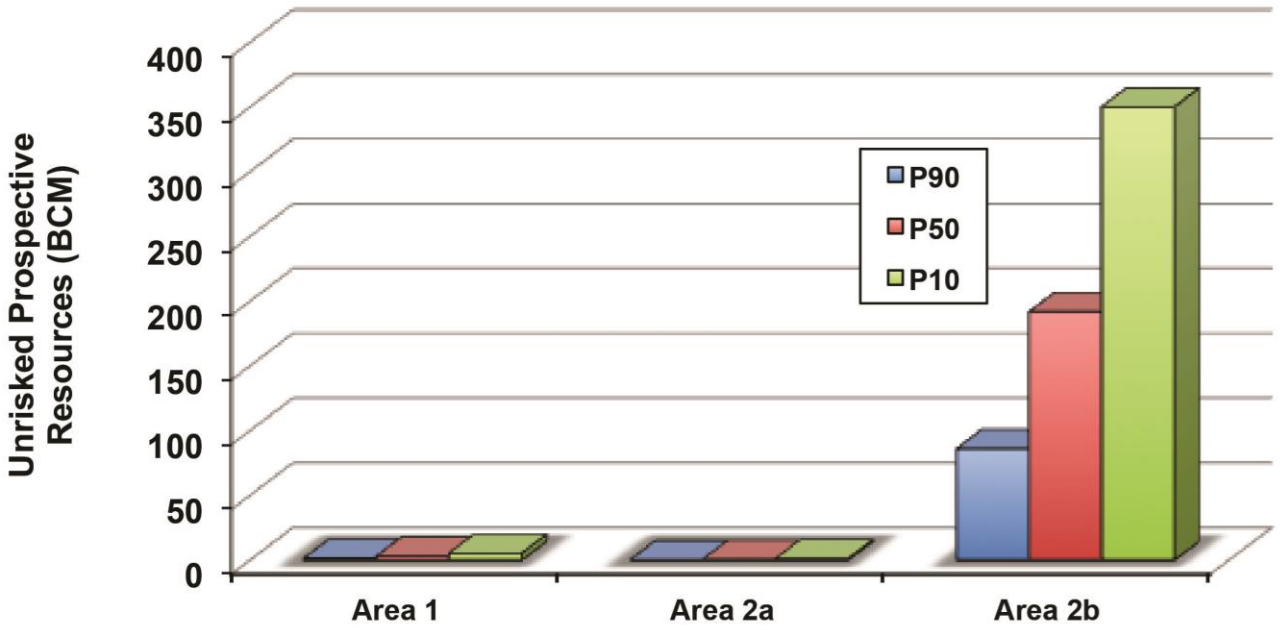


# Results of Assessment – Ongi River

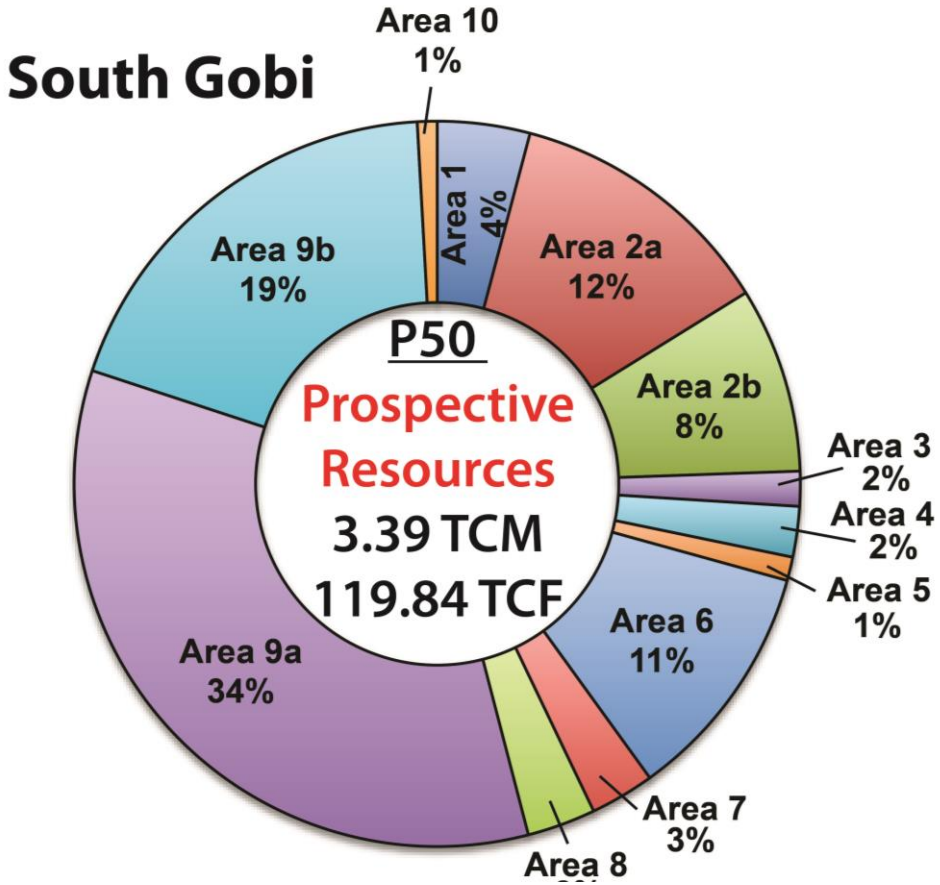
## Prospective Resources

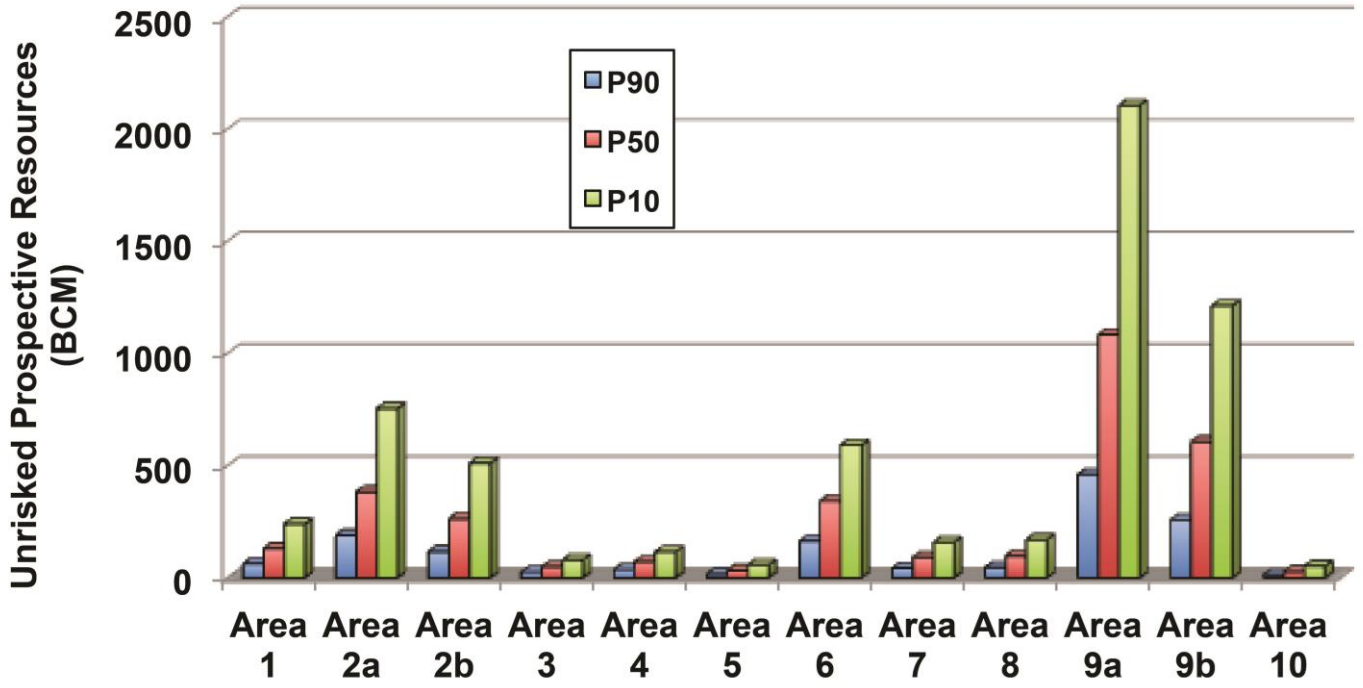


# Results of Assessment – South Gobi

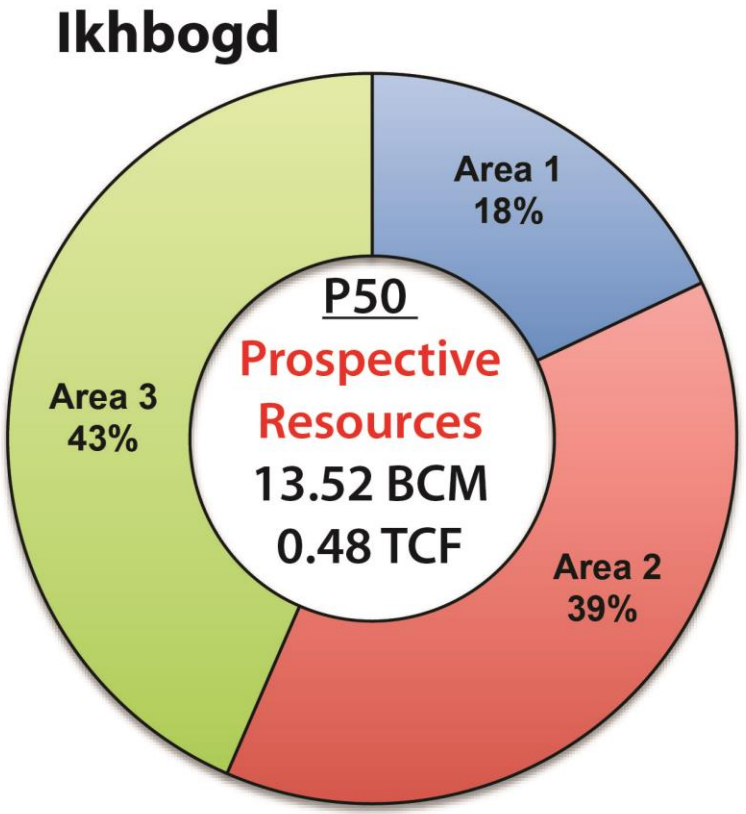
## Prospective Resources

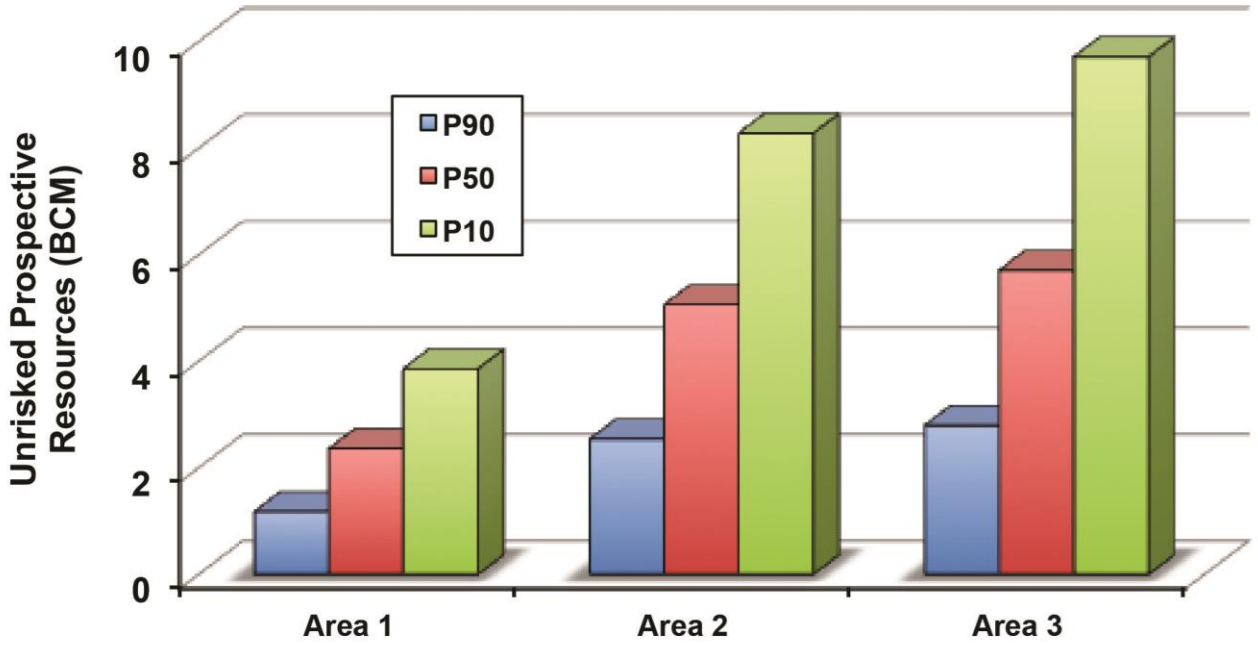


# Results of Assessment –

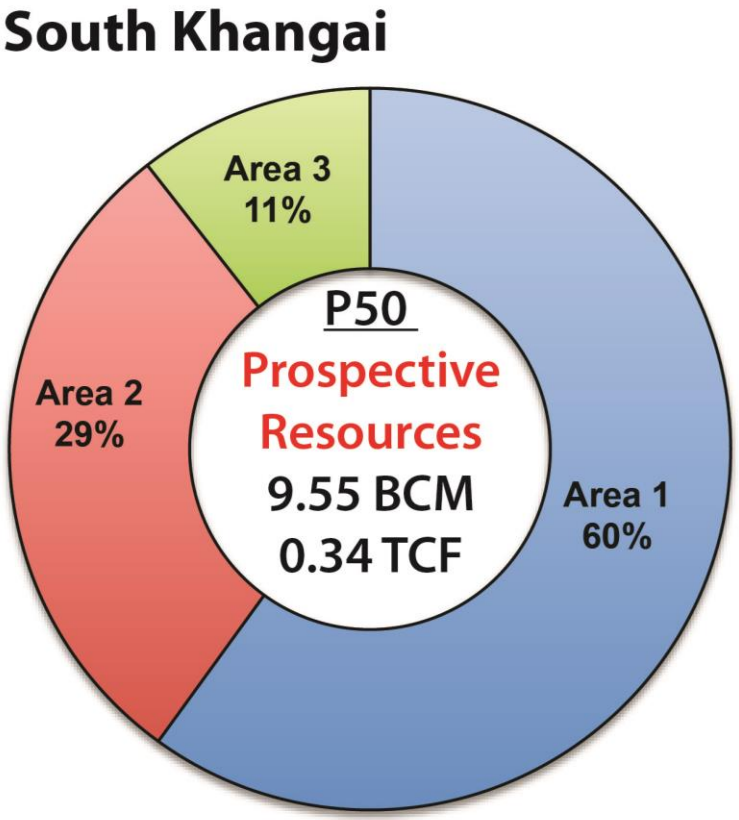
## Prospective Resources

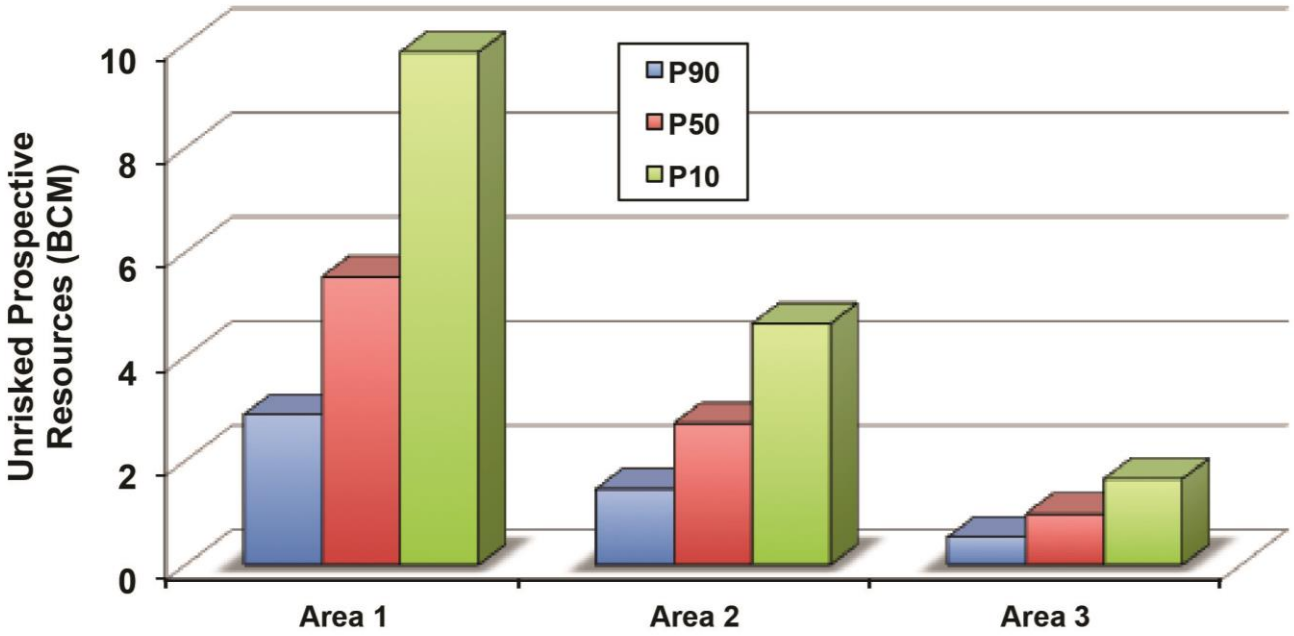


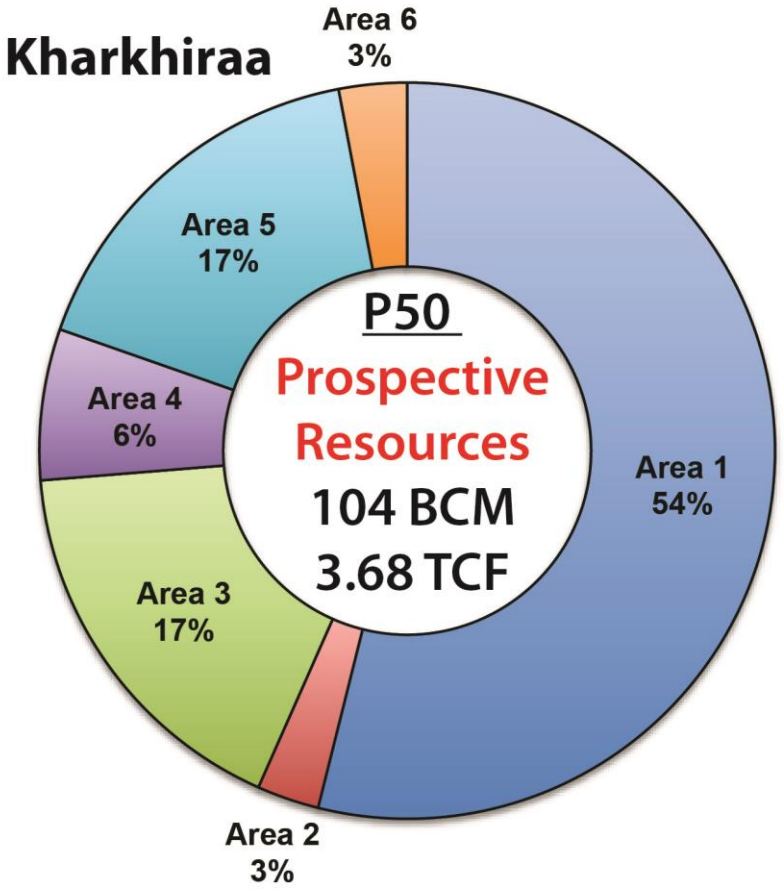
# Results of Assessment – South Khangai

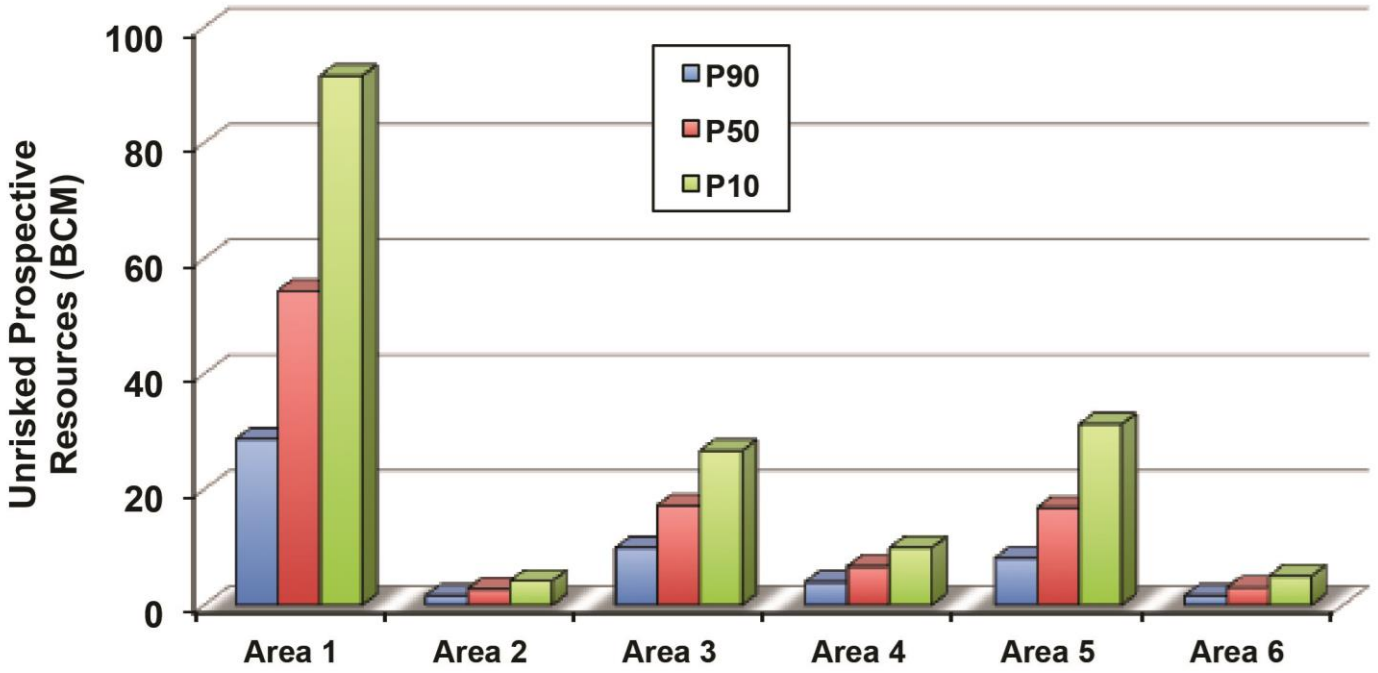
## Prospective Resources



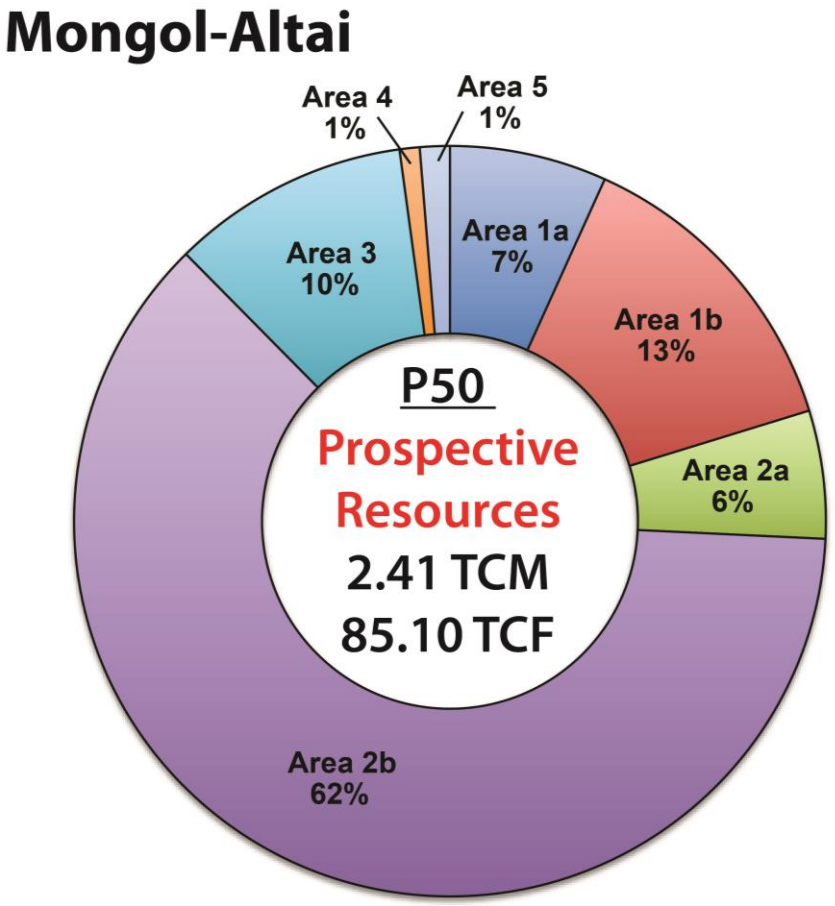
# Prospective Resources

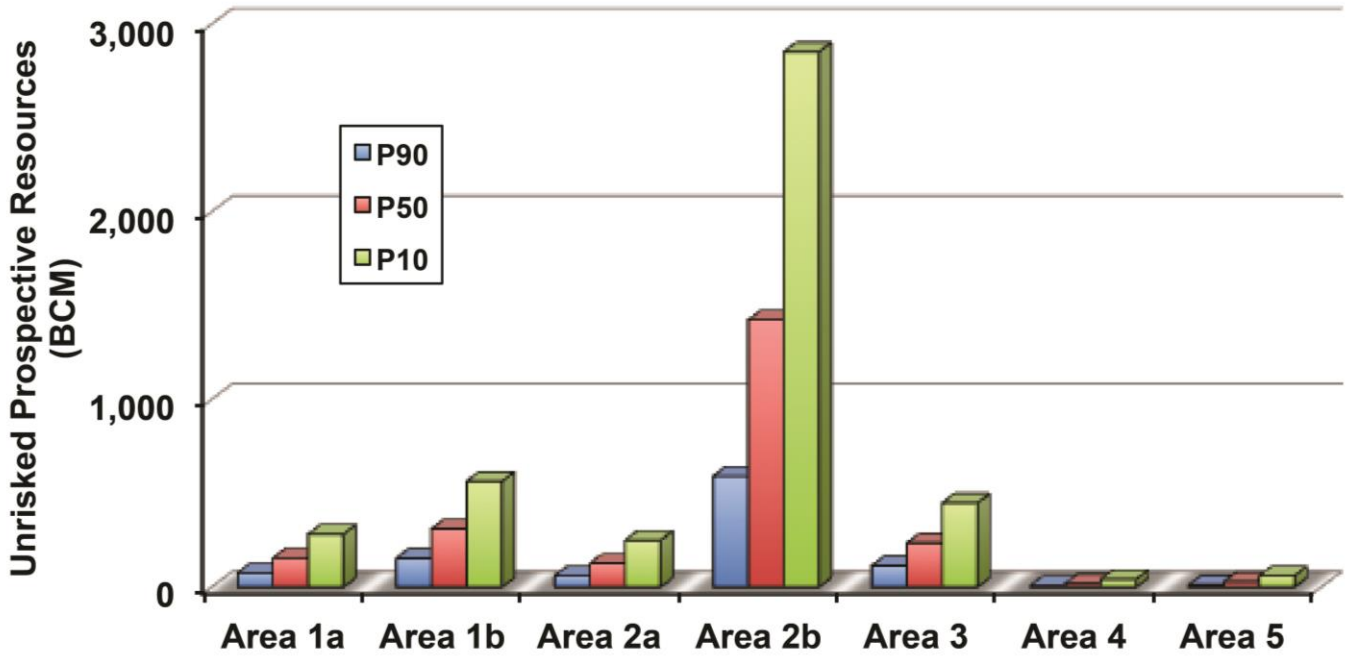


# Results of Assessment – Mongol-Altai

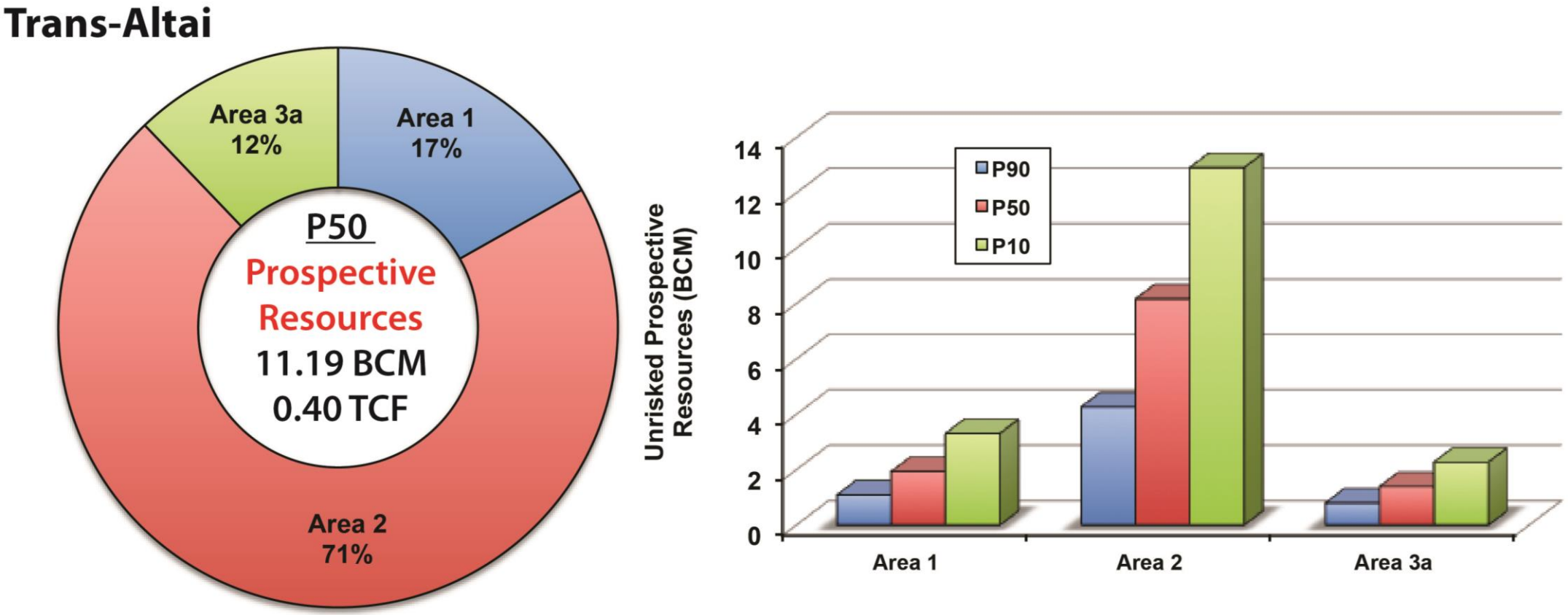
## Prospective Resources



# Results of Assessment – Trans-Altai

## Prospective Resources



# Recommendations

1. Make the CBM data (electronic and hard copy) that this report has relied upon freely available online, in much the way that some countries do, such as:

   a. Australia: https://geoscience.data.qld.gov.au , https://georesglobe.information.qld.gov.au/ , http://www.bom.gov.au/water/groundwater/explorer/map.shtml

   b. New Zealand: https://www.nzpam.govt.nz/maps-geoscience/

   c. USA: https://wogcc.wyo.gov/data, https://wsgs.maps.arcgis.com/apps/webappviewer/index.html?id=09ebeedba94048a0b1ec4dcfc71eb9b5

2. The GIS files of the areas of assessment used in this report should also be made freely assessable online. This will provide a starting point for any researcher or potential investor for expansion of resources.

# Recommendations (con't)

3. Conduct sample collection campaigns for defining the basic, important properties of coal reservoirs, which are fundamental to the foundational knowledge of CBM reservoirs and plays such as:
    a. Collection of fresh, well documented coal samples from all coal regions and all important areas and test for:
        I. Maximum gas holding capacity ('adsorption isotherm' tests)
        II. Proximate (% ash yield, % moisture, % volatile matter) and sulfur analyses
        III. Vitrinite reflectance
        IV. Maceral analysis
4. In areas of known CBM resources, make the 1:200,000 scale geological maps available online, either freely available or for a nominal fee.
5. Extend basin areas or delineate their boundaries more precisely using existing air-borne magnetics and gravity surveys as well as using existing seismic line interpretations or re-interpretations.

# Recommendations (cont'd)

6. Collect, consolidate and centralise the key reservoir and hydrogeological data that is needed for CBM development and make this information and data available to potential investors and researchers, including:
    a. Coal permeability measurements
    b. Reservoir pressure measurements

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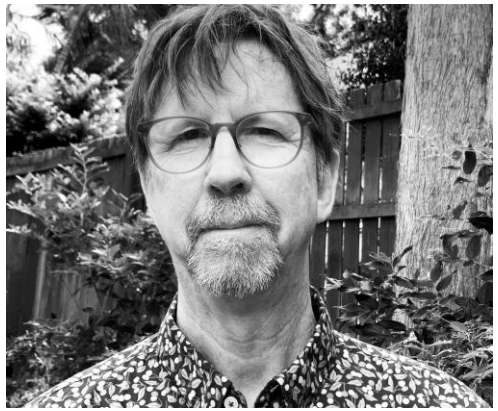

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# Got Questions?

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