GISC 6387 PROJECT: PREDICTING OIL WELL YIELDS IN RUSSIA

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3 August 2020

PROJECT PURPOSE

Predict the yield of oil wells in Russia based on their similarity to other wells with known production.

REVIEW OF LITERATURE

- Petroleum resource modeling
- Geology of oil fields
- Soviet infrastructure

REVIEW OF LITERATURE: USGS

- United States Geological Survey
- 2000 World Petroleum Assessment
  - Worldwide oil and natural gas production capacity
- Methodology [Charpentier and Klett (2005)]
  - Geological factors
  - Exploration history
    - Larger accumulations generally found earlier, but
    - Economic, technological, and political factors can also affect exploration trend

REVIEW OF LITERATURE: HAMIDA, ET AL. (2017)

- Explores variety of geometry-based optimization approaches for well placement in oil fields
- Measurement for quantitative similarity between wells
- Journal of Petroleum Science and Engineering

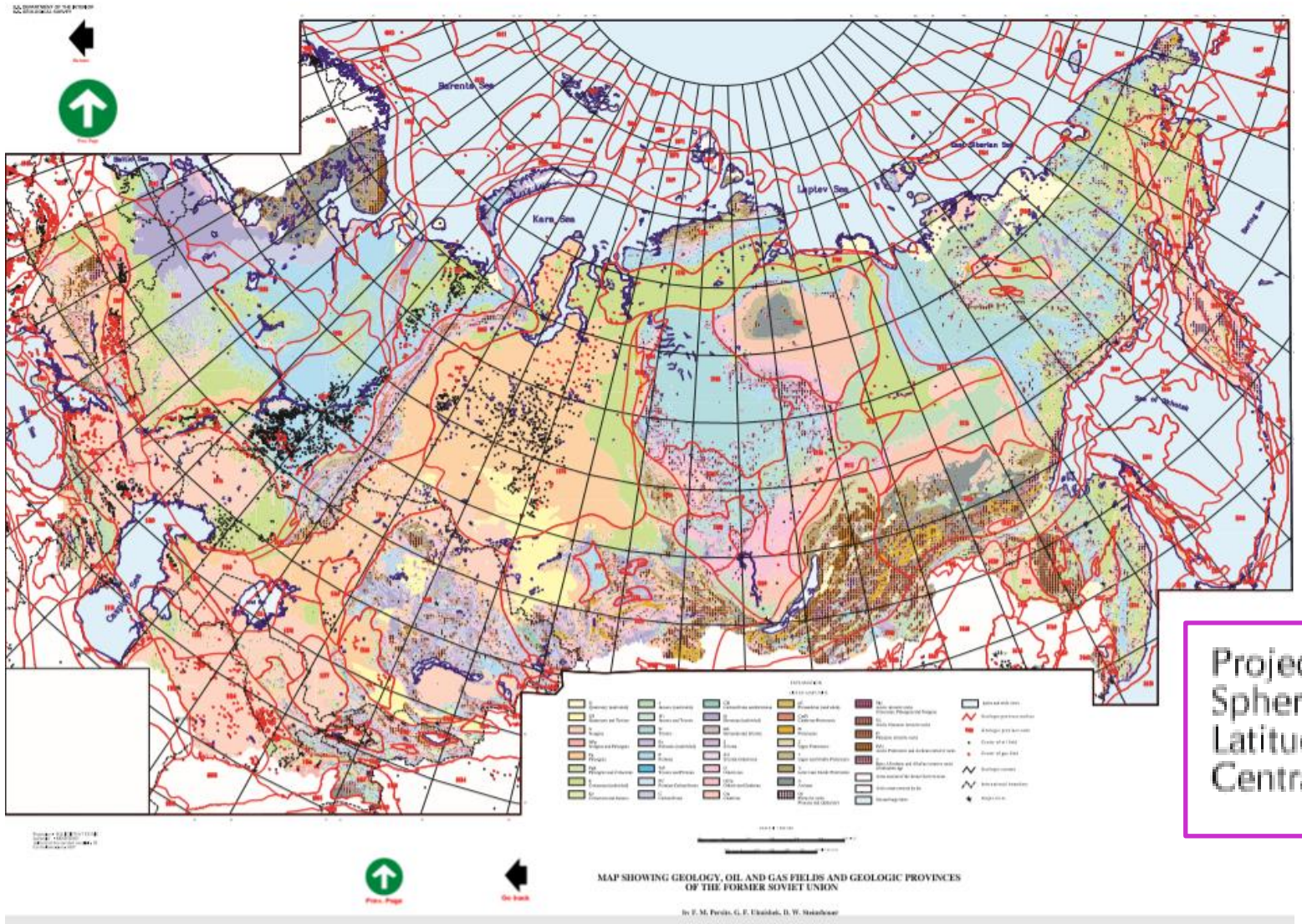
REVIEW OF LITERATURE: OTHER PAPERS

- Ivanov et al. (2018). *The main factors affecting the distribution of oil fields in the West Siberian Platform.*
  - Proximity to Triassic rifts
  - Thickness and geological age of the basement
- Campbell (1968). *Economic Reform in the USSR.*

STUDY AREA AND DATA SOURCES: USGS

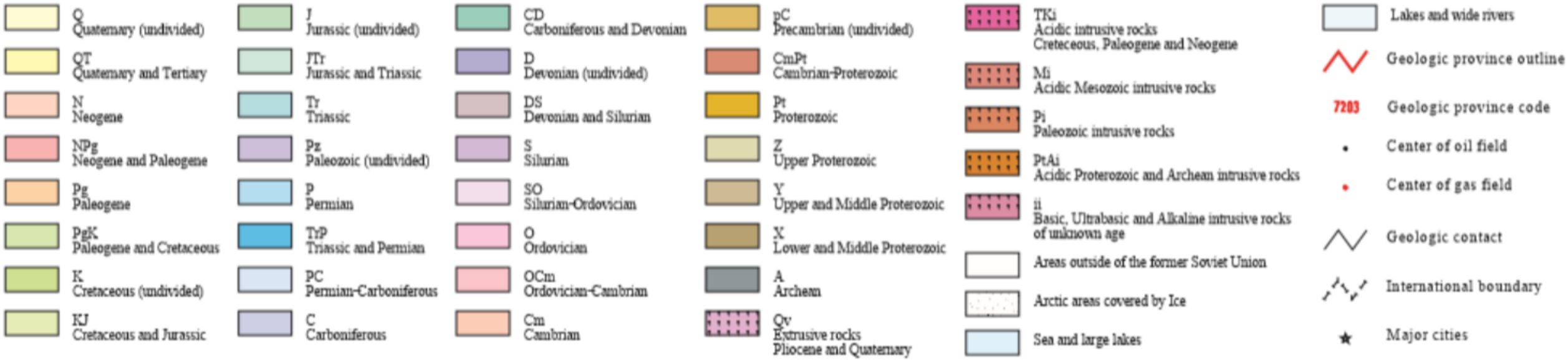
- USGS assessment of oil production capacity of oil fields in Former Soviet Union
- Map to a shapefile of geological provinces

STUDY AREA AND DATA SOURCES: USGS



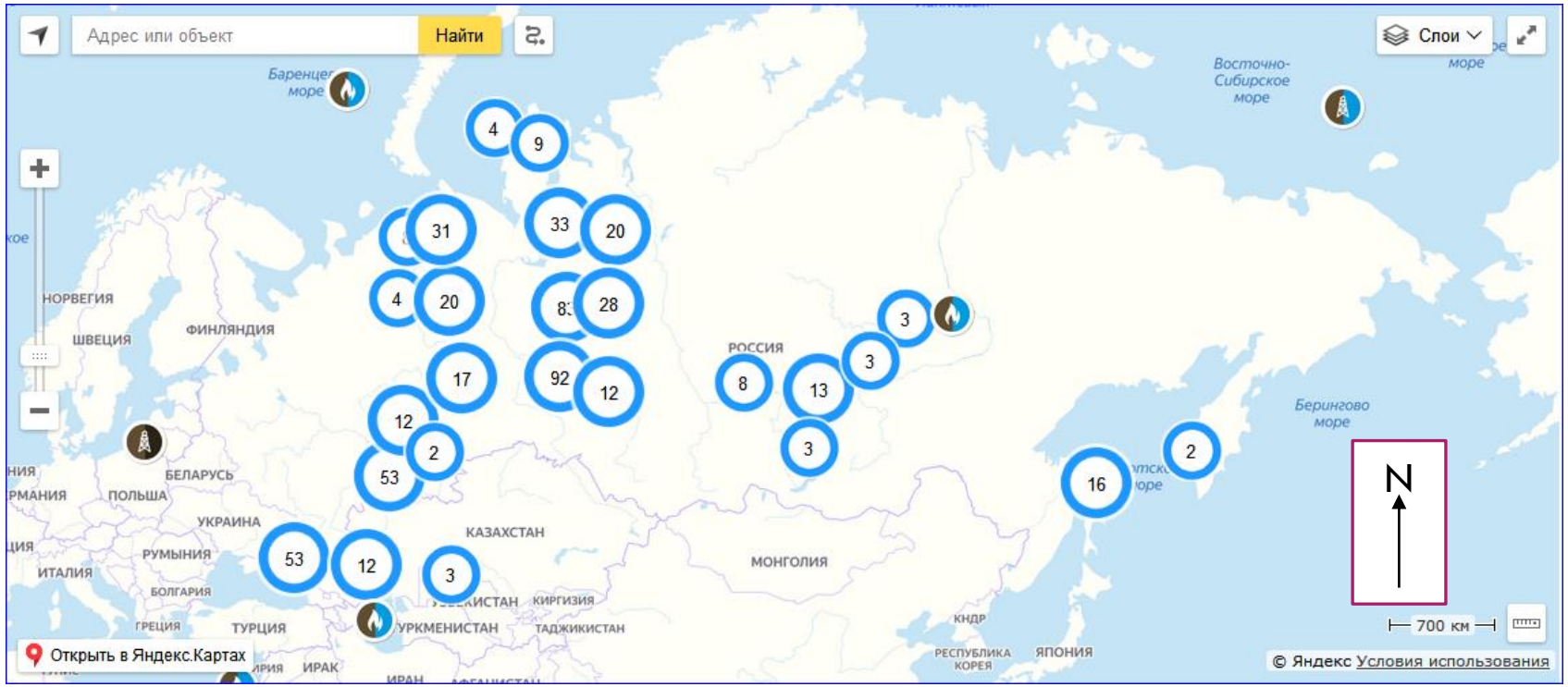
Projection - EQUIDISTANT CONIC
Spheroid - KRASOVSKY
Latitude of the standart parallel - 58
Central Meridian - 100°

STUDY AREA AND DATA SOURCES: USGS



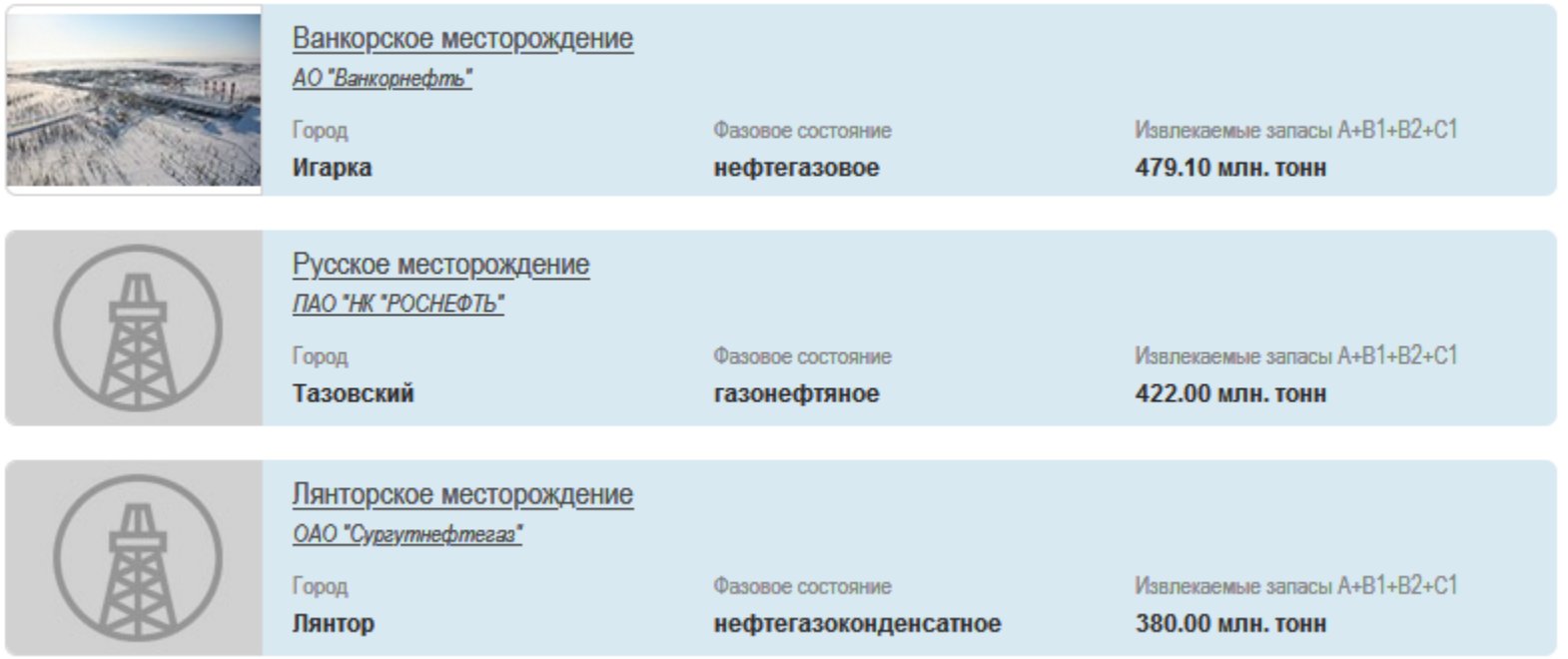
STUDY AREA AND DATA SOURCES: ENERGYBASE.RU

- Energybase.ru provides the location (city) of 558 currently operating oil and gas wells in Russia



STUDY AREA AND DATA SOURCES: ENERGYBASE.RU

- Oil/gas production data available for 98 wells
- Example:



WEB SCRAPING ENERGYBASE.RU

```
wellsdat <- NULL
for (pg in 1:28){
  webpage <- paste0("https://energybase.ru/oil-gas-field/index?page=", pg) %>%
    read_html(encoding = "utf-8")
  out <- webpage %>%
    html_nodes("div.name, div.info") %>%
    html_nodes("a, small a, small, div.value") %>%
    html_text()
  out <- out[grepl("\n", out) == FALSE]
  wells <- as.data.frame.vector(out)
  wellsdat <- rbind(wellsdat, wells)
}
write.csv(wellsdat, "wellsdat.csv", row.names = FALSE)
```

WEB SCRAPING ENERGYBASE.RU

```
sites <- NULL
for (pg in 1:28){
  webpage <- paste0("https://energybase.ru/oil-gas-field/index?page=", pg) %>%
    read_html(encoding = "utf-8")
  out <- webpage %>%
    html_nodes("div.name > a") %>%
    html_attr("href")
  site <- as.data.frame.vector(out)
  sites <- rbind(sites, site)
}
write.csv(sites, "sites.csv", row.names = TRUE)
```

WEB SCRAPING ENERGYBASE.RU

```
<div class="item">
    <small>
        Координаты:
    </small>
    <br>
    <a href="#yandex-map">Широта: 45.000278</a><br><a href="#yandex-map">Долгота: 48.561944</a>          </div>
```

```
sites <- read.csv("sites.csv")
coords <- NULL
for (i in 1:nrow(sites)){
  site <- sites$out[i]
  webpage <- paste0("https://energybase.ru", site) %>%
    read_html(encoding = "utf-8")
  out <- webpage %>%
    html_nodes("section.contacts div.item > a") %>%
    html_text()
  coord <- as.data.frame(cbind(out[1], out[2]))
  coords <- rbind(coords, coord)
}
```

```
colnames(coords) <- c("lat", "long")
coords$id <- as.numeric(row.names(coords))
coords$lat <- str_extract(coords$lat, "[[:digit:]].*$")
coords$lat <- as.numeric(coords$lat)
coords$long <- str_extract(coords$long, "[[:digit:]].*$")
coords$long <- as.numeric(coords$long)
write.csv(coords, "coords.csv", row.names = FALSE)
```

TRANSLATING WELL TYPES IN ENERGYBASE.RU

```
types_ru <- unique(wells_all$type)
types_ru <- paste0("^", types_ru, "$")
types_en <- c("oil-gas", "gas-oil", "oil-gas-condensate", "oil",
"gas-condensate", "gas")
wells_all$type_ru <- wells_all$type
for (i in 1:length(types_ru)){
  wells_all$type <- gsub(types_ru[i], types_en[i], wells_all$type)
}
```

Type	Known Production	Unknown Production
Gas	0	49
Gas-condensate	4	77
Gas-oil	3	4
Oil	54	195
Oil-gas	12	48
Oil-gas-condensate	22	82

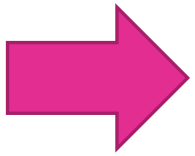
METHODOLOGY: INVERSE-DISTANCE WEIGHTING

- Inverse-distance weighting of petroleum yield using
- $p_i = \sum_{j=1}^{n} \frac{1}{{d_{ij}}^2} p_j / \sum_{j=1}^{n} \frac{1}{{d_{ij}}^2}$,

where p_i is predicted petroleum yield for well i, p_j is known petroleum yield for well j, and d_{ij} measures the distance between two wells i and j

METHODOLOGY: INVERSE-DISTANCE MATRIX

$$\frac{1}{A_{249,249} \bullet A_{249,249}}$$



$$D_{249,249}$$

Distance Matrix
(Great-circle distance,
in kilometers)

Inverse Distance Matrix
(symmetrical)

```
writeDist(rdist.earth(oil.mtrx, miles = FALSE, R = 6366.71), file = "oil.mtrx.csv")
oil.mtrx <- read.delim("oil.mtrx.csv", header = FALSE, sep = " ")
oil.mtrx <- as.matrix(oil.mtrx[2:250,2:250])
for(i in 1:dim(oil.mtrx)[1]) {oil.mtrx[i,i] = 0}
mtrx.dist.inv <- ifelse(oil.mtrx!=0, 1/(oil.mtrx*oil.mtrx), oil.mtrx)
dist.inv <- as.data.frame(mtrx.dist.inv)
dist.weights.sum <- as.data.frame(rowSums(dist.inv))
```

METHODOLOGY: GEOLOGICAL PROVINCE MATCH

GLG Vector (Character)

Geological Match Matrix (binary and symmetrical)

$$G_{249,249}$$

```
mtrx.glg <- matrix(NA, nrow = 249, ncol = 249)
for (i in 1:nrow(oil.wells)){
  for (j in 1:nrow(oil.wells)){
    mtrx.glg[i,j] <- ifelse(
      oil.wells$GLG[i] == oil.wells$GLG[j], ifelse(
        i != j, 1, 0),
       0)
  }
}
glg <- as.data.frame(mtrx.glg)
glg.weights.sum <- as.data.frame(rowSums(glg))
```

METHODOLOGY: PRODUCTION WEIGHTS

Production Vector (numeric) Production Weights Vector (binary)

$O_{249,1}$  $V_{249,1}$

Min: 1.80
Mean: 63.87
Max: 360.0
Not Missing: 54
Missing: 195
N: 249

```
prod <- as.matrix(oil.wells$prod)
prod[is.na(prod)] <- 0
prod.weights <- prod
prod.weights[is.na(prod.weights)] <- 0
prod.weights[prod.weights > 0] <- 1
```

METHODOLOGY: WEIGHTS CALCULATION

Inverse Distance Matrix

Geological Match Matrix

Production Weights Vector

Weights vector

$$D_{249,249}G_{249,249}V_{249,1} = W_{249,1}$$

dist.glg.weights.all <- mtrx.dist.inv %*% mtrx.glg %*% prod.weights

METHODOLOGY: WEIGHTED PREDICTIONS

Inverse Distance Matrix

Geological Match Matrix

Production Vector

Weights vector

Predicted production vector

$$P_{249,1} = \frac{D_{249,249} G_{249,249} O_{249,1}}{W_{249,1}}$$

```
dist.glg.weighted.pred <- mtrx.dist.inv %*% mtrx.glg %*% prod
dist.glg.pred <- dist.glg.weighted.pred/dist.glg.weights.all
```

METHODOLOGY: EVALUATING THE PREDICTIONS

Predicted production vector

Production Vector

$$\sum \left\{ P_{249,1} - O_{249,1} \right\}^2$$

Min: 8.332
Mean: 57.014
Max: 108.477
Not Missing: 54
Missing: 195
N: 249

Min: 1.80
Mean: 63.87
Max: 360.0
Not Missing: 54
Missing: 195
N: 249

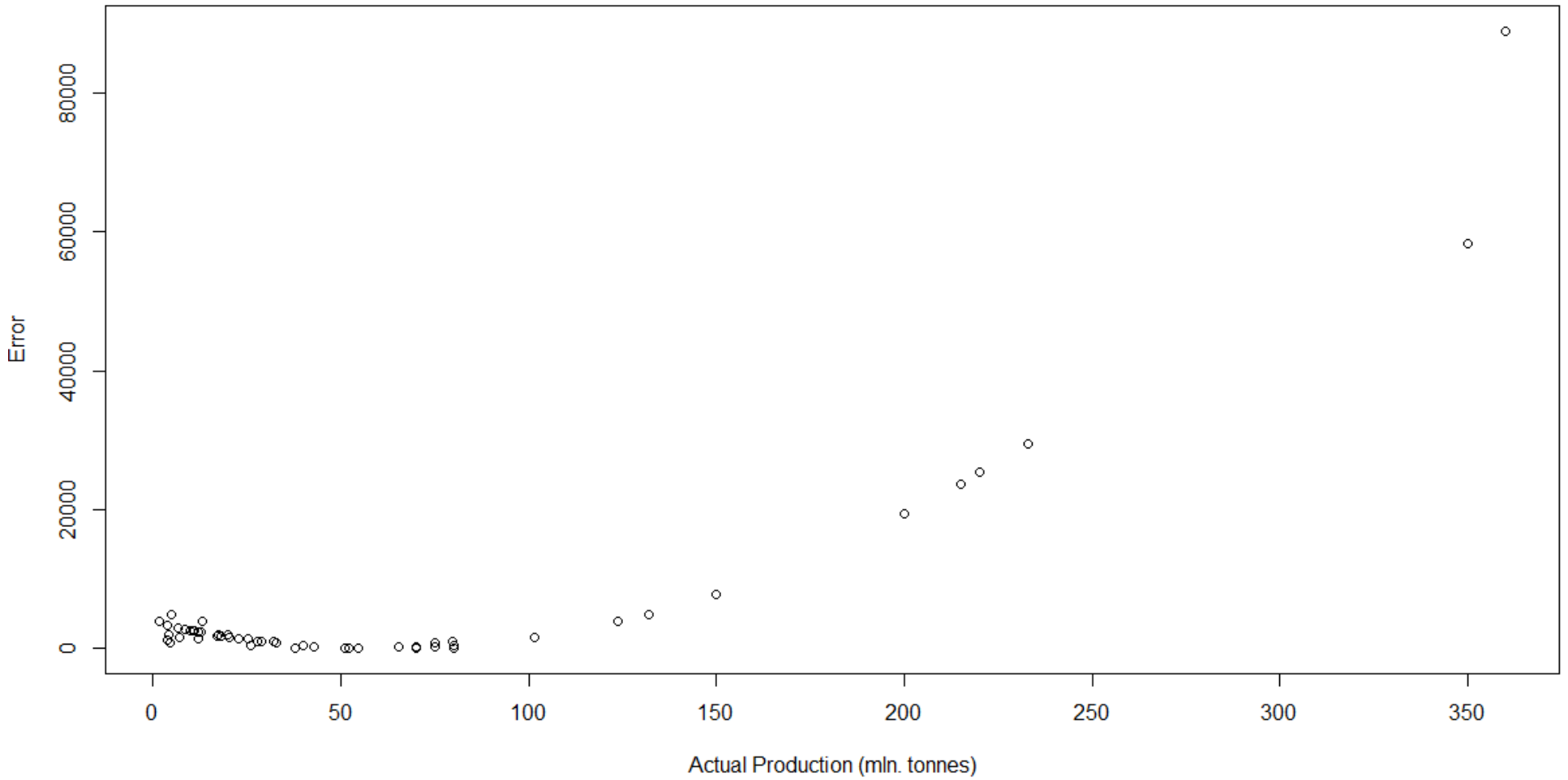
Sum of squared errors

Inverse-distance weighted: 513,153.1

Geological match weighted: 517,393.6

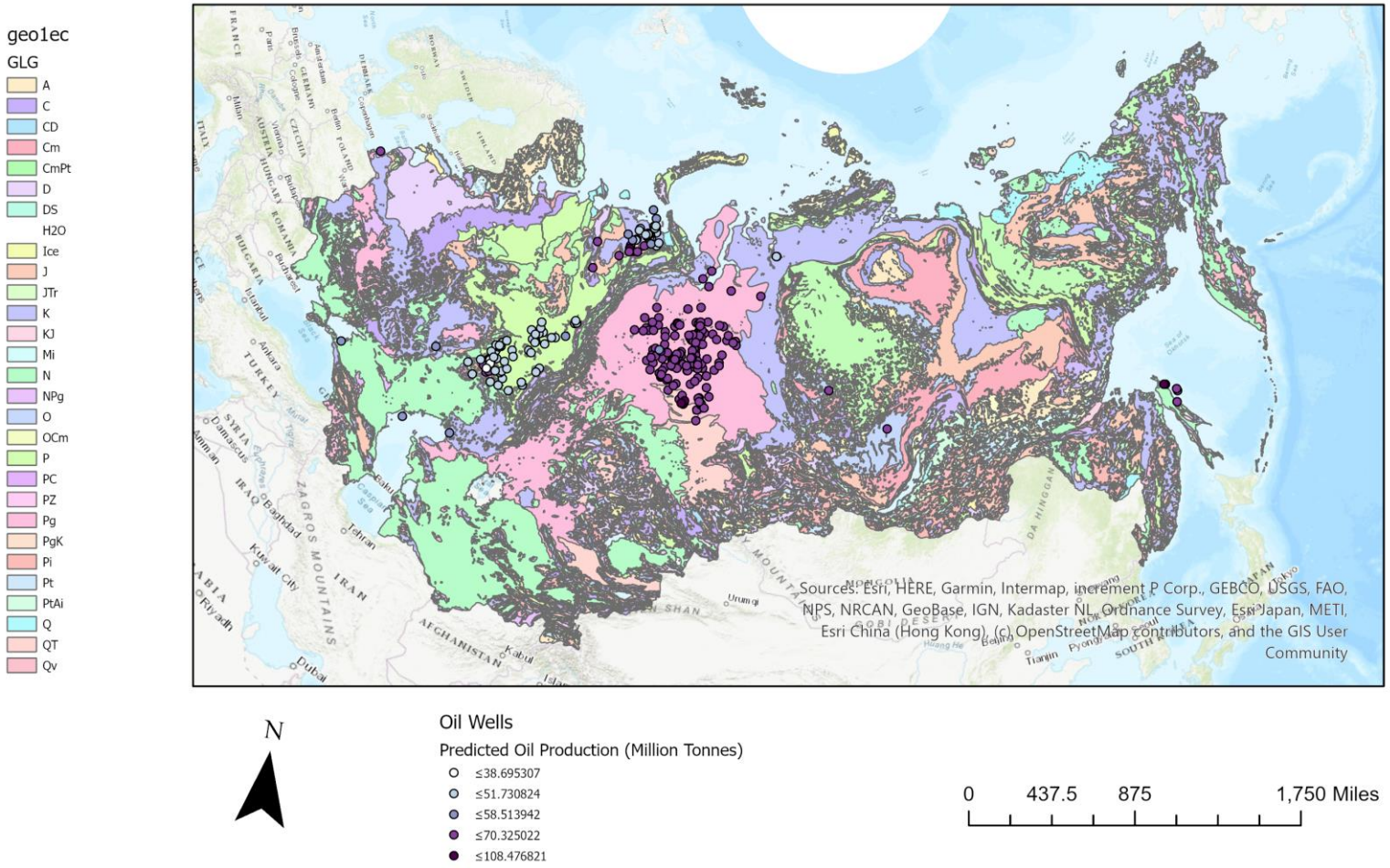
Weighted by both: 327,098.6

METHODOLOGY: EVALUATING THE PREDICTIONS



PREDICTED OIL PRODUCTION

Map of the Geological Provinces of the Former Soviet Union



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