World Experience in Shale Oil & Gas Industry and prospects of its Development in Georgia

Results of Preliminary Study of Shale Gas and Shale Oil Perspectives in Georgia

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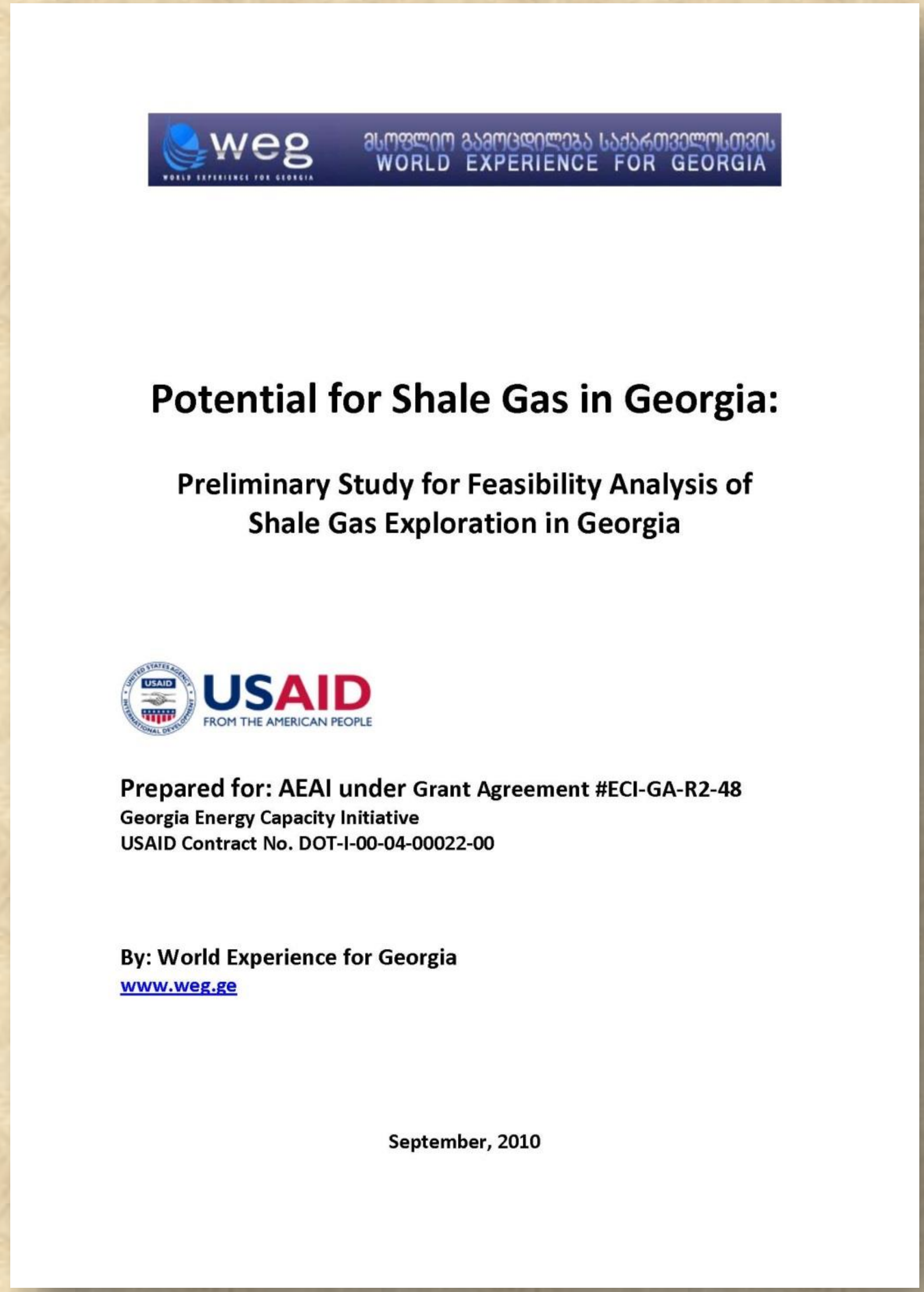
Batumi - 2014

In 2010 USAID funded and supported by Georgian Government project of preliminary study of **POTENTIAL FOR SHALE GAS IN GEORGIA** was conducted By:

- World Experience for Georgia – WEG
- Experts from Georgian Universities, and
- Hydrodynamics Ltd., USA



WORLD EXPERIENCE FOR GEORGIA

Potential for Shale Gas in Georgia:

Preliminary Study for Feasibility Analysis of Shale Gas Exploration in Georgia

USAID
FROM THE AMERICAN PEOPLE

Prepared for: AEAI under Grant Agreement #ECI-GA-R2-48
Georgia Energy Capacity Initiative
USAID Contract No. DOT-I-00-04-00022-00

By: World Experience for Georgia
www.weg.ge

September, 2010

STRATEGY OF THE PROJECT

Gas Shales Identification Criteria

- USA and other countries' experience;
- Identification of key parameters

Identification of Possible Gas Shales

- Study of Georgia's sedimentary formations

Screening

- Identification of screening criteria
- Separate approach for East and West Georgia

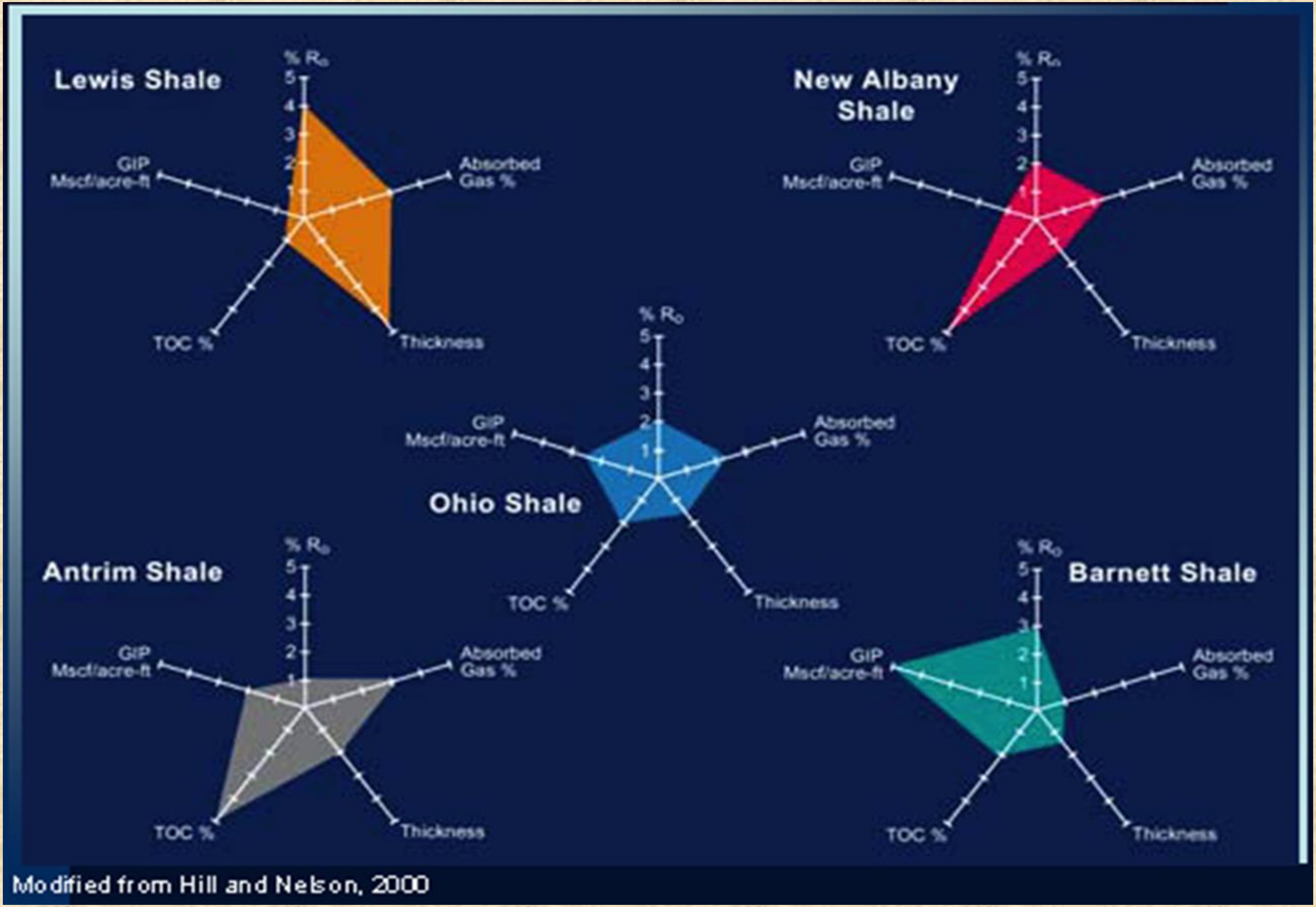
MEETINGS AND CONSULTATIONS

- The Ministry of Energy
- National Agency of Oil and Gas
- Georgian Oil and Gas Corporation
- With all main licensee companies
- USAID Georgia
- Georgian Agency of Spatial Information
- Caucasian Institute of Mineral Resources
- Institute of Geology of the Academy of Sciences
- With individual experts

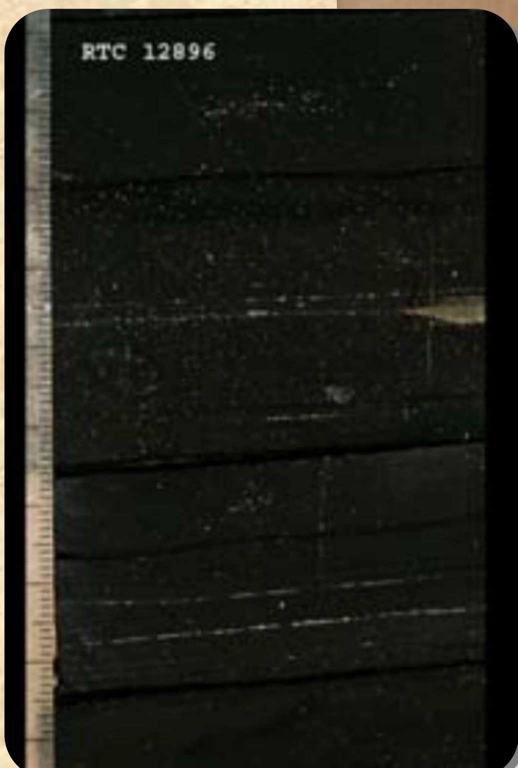
Main Gas Shale Formations of the USA

Basin	Formation	Rock Type	Age
Uinta	Green River	Dolomite	Eocene
Los Angeles	Monterey	Shale (silica rich)	Miocene
Texas/Louisiana/Missisippi Salt	Haynesville	Black Shale (clay rich)	Jurassic
San Juan	Lewis	Shale	Cretaceous
Raton	Pierre	Black Shale (clay rich)	Cretaceous
Williston	Gammon	Shale	Cretaceous
Denver	Niobrara	Chalk (rich in organic material)	Cretaceous
Forth Worth	Barnett	Black Shale (clay rich)	Mississippian
Williston	Bakken	Shale with interbedded Dolomite	Devonian-Missippian
Anadarko	Woodford	Black Shale (clay rich)	Devonian-Missippian
Arkoma	Woodford	Black Shale (clay rich)	Devonian-Missippian
Illinois	New Albany	Black Shale (clay rich)	Devonian
Michigan	Antrim	Black Shale (clay rich)	Devonian
Appalachian	Cinnamon, Fredonia, Macellus	Shale (clay rich)	Devonian

SHALES ARE DIFFERENT



DIFFERENT TYPES OF GAS SHALES



THE CRITERIA

What are Shale Gas and Shale Oil Deposits?

① Organic-Kerogen Rich Clastic Sedimentsa

② Source rock for oil & gas deposits within a geologic basin

③ Unconventional Resource

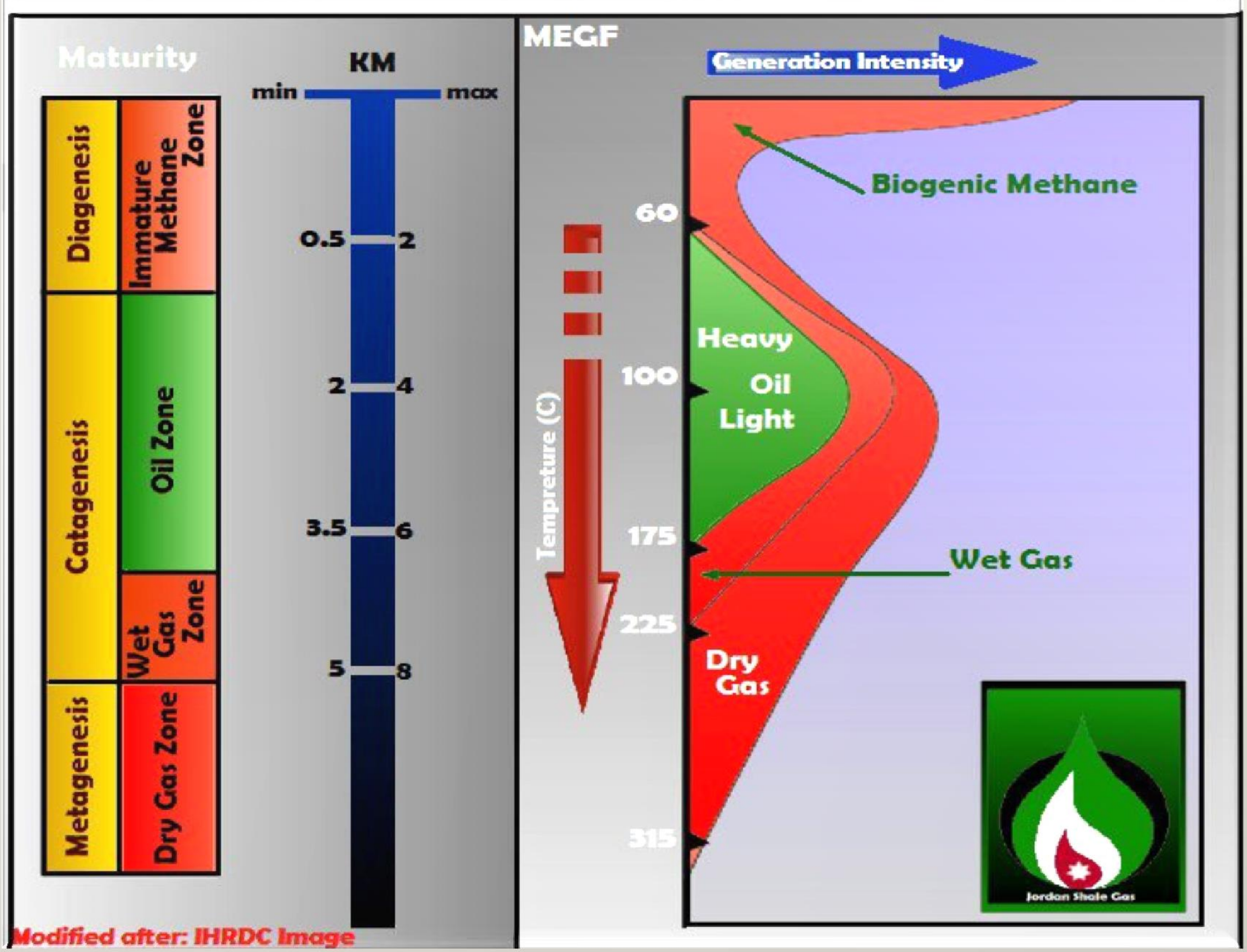
   ① Low Permeability

   ② As a rule requires unique drilling and development technology

Gas Shale Definition

- Even in English there are numerous definitions of traditional shale – a sedimentary rock formed by the consolidation of mud, silt or clay and having the property of splitting into thin layers parallel to its bedding planes.
- In general, modern definitions of Gas Shales left aside mineralogy, degree of maturity and metamorphism and include only statements about sediment rocks with certain sizes of grain and states in general that Gas and Oil Shales are serve as a source and reservoir for the *in situ* generated hydrocarbons. Some definitions also mentioning kerogen type and permeability.
- Initially by many our experts it was assumed that Gas Shales and traditional shales are the same. Such approach left beyond the range of consideration very promising lithological formations constituting almost ¾ of formations which can be qualified as Gas and/or Oil Shales.

Diagenesis and Maturity of Oil Prone Source

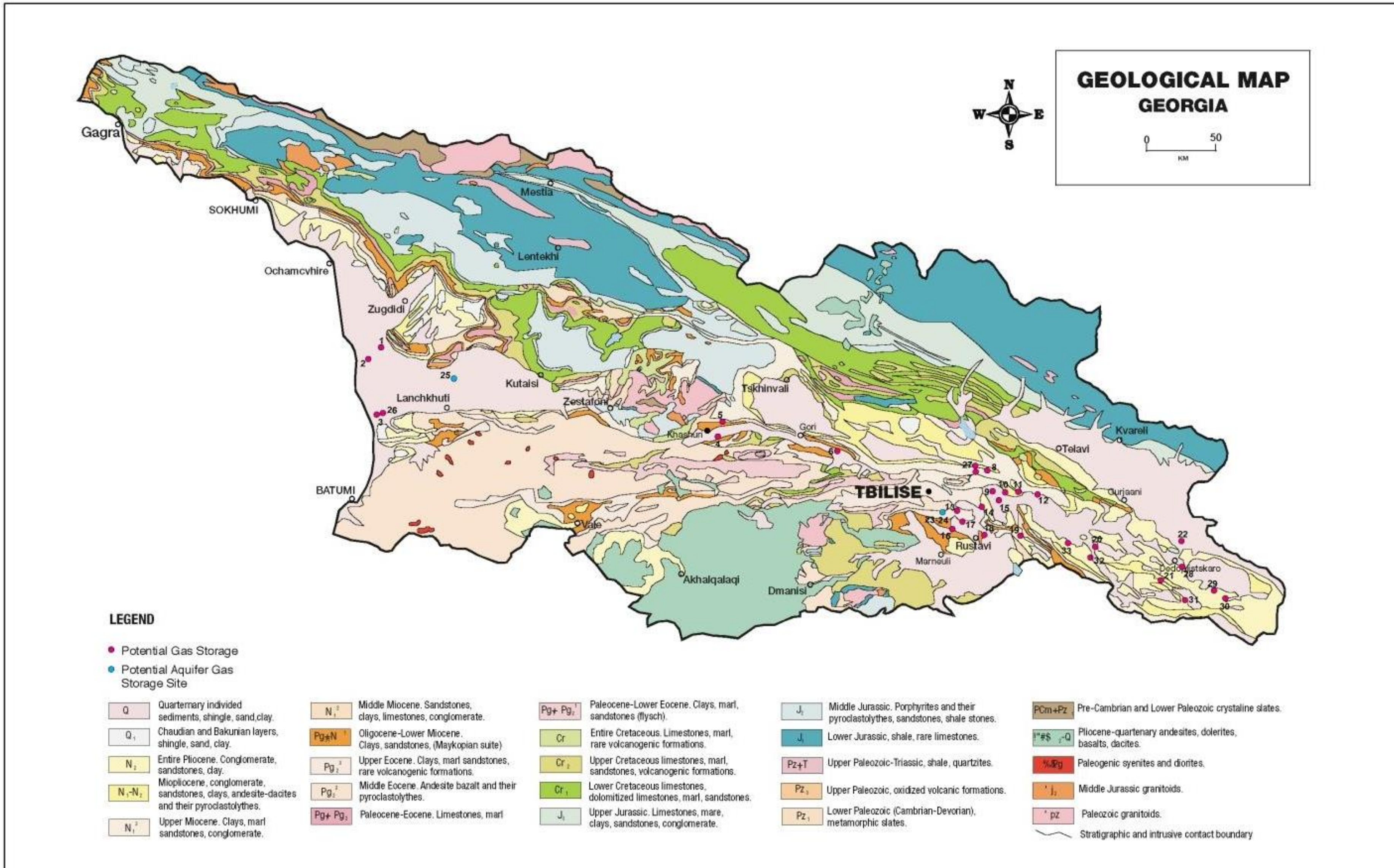


Kerogen type

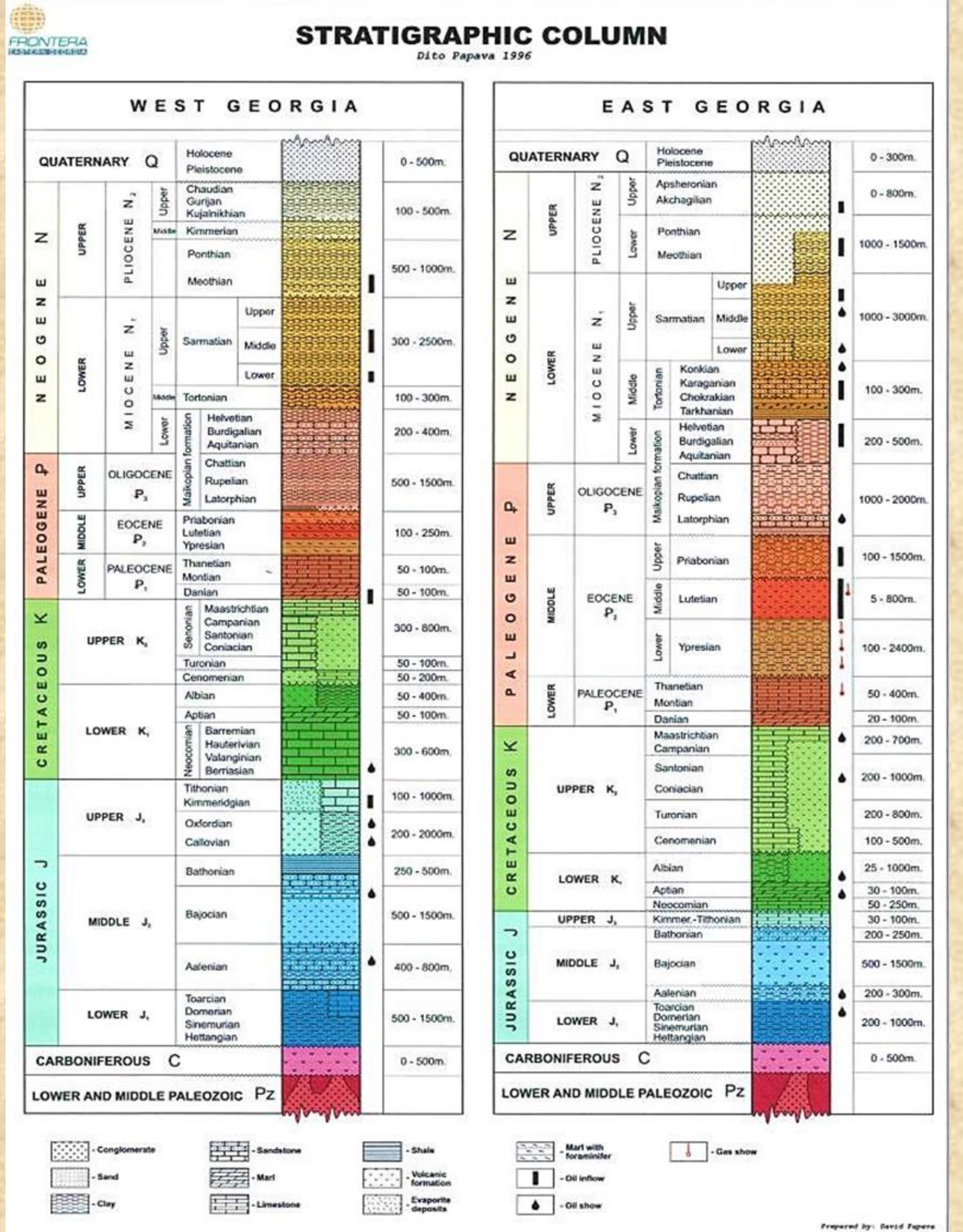
- All shale gas plays are in oil prone, marine "Type II" kerogen facies
- So called "gas prone" or coaly OM are not significant!

Maceral	Kerogen Type	Original OM
Alginite	I	Fresh-water algae
Exinite	II	Pollen, spores
Cutinite	II	Land-plant cuticle
Resinite	II	Land-plant resins
Liptinite	II	All land-plant lipids; marine algae
Vitrinite	III	Woody and cellulosic material from land plants
Inertinite	IV	Charcoal; highly oxidized or reworked material of any origin

Primarily Oil Bearing Sediments in Georgia



Occurrences of Gas and Oil shows in different formations of sedimentary complex of West and East Georgia



According to D. Papava
by courtesy of FRONTERA

HYDROCARBONS BEARING FORMATIONS OF GEORGIA

Eastern Georgia

#	Complex	Composition	Thickness (m)	Lithology	Area of distribution	Shale
Eastern Georgia						
1	**Lower Pliocene (Shiraki suite)**	Terrigenous	up to 2500	Clays, sandstones, conglomerates	Zonal in South Kakhetian and local in Alazani-Agrichai OGZs	
2	**Upper Miocene**	Terrigenous	1450-2250	Sandy-clay sediments with interlayers of conglomerates and oolithic limestones	Zonal in Kartli and South Kakhetian and local in Near-Tbilisi OGZs	+
3	**Middle Miocene**	Terrigenous	40-600	Clays (shales) with interlayers of sandstones	Zonal in Kartli and South Kakhetian OGZ; local in Near-Tbilisi OGZ	+
4	**Oligocene-Lower Miocene**	Terrigenous	500-1500 and more	Clays (shales) and sandy-clays sediments	Regional (except Achara-Trialeti zone)	+
5	**Upper Eocene**	Terrigenous	100-3000	Clays(?) and shales with interlayers of sandstones	Regional (except Achara-Trialeti zone)	+
6	**Middle Eocene**	Volcanogenic	200-600	Volcanogenic-sedimentary rocks (tuffs, lavas etc.)	Zonal in Near-Tbilisi, Kartli and South Kakhetian OGZs;	
7	**Paleocene-Lower Eocene**	Terrigenous	up to 3500-4000	Sandy-clay sediments with interlayers of limestones and marls	Regional	
8	**Turonian-Danian**	Carboniferous	200-1200	Limestones and marls; lower occur volcanogenic rocks	Regional	
9	**Neokom-Aptian**	Carboniferous	up to 1000-1500	Limestones, marls; locally interlayers of sandstones and volcanogenic rocks	Regional	
10	**Upper Jurassic**	Terrigenous	500-1500 and more	Upper: speckled clays, sandstones; lower: sandy-clays with interlayers of coal-bearing rocks; lowest: volcanogenic rocks	Regional	+
11	**Upper Bajocian-Batonian**	Terrigenous	up to 1000	Alternation of shales and sandstones	Regional (?)	+
12	**Liassic**	Terrigenous	200-1200 maybe more	Shales with interlayers of sandstones and rear interlayers of limestones	Regional	+

OGZ – Oil and Gas Zone

HYDROCARBONS BEARING FORMATIONS OF GEORGIA

Western Georgia

#	Complex	Composition	Thickness (m)	Lithology	Area of distribution	Shale
Western Georgia						
1	**Meothian**	Terrigenous	up to 1000	Conglomerates, clay with interlayers of sandstones	Zonal in Guria OGZ; local in Abkhazeti-Samegrelo and Rioni OGZ	
2	**Upper Miocene**	Terrigenous	up to 2000-2500	Sandy-clay sediments	Zonal in Guria and Abkhazeti-Samegrelo OGZ; local in Rioni OGZ	+
3	**Oligocene-Lower Miocene**	Terrigenous	200-1900	Clays (shales) and sandy-clay sediments	Regional	+
4	**Middle Eocene**	Volcanogenic	1300-4000	Volcanogenic-sedimentary rocks (tuffs, tuff-aleurolites, andesites, basalts, marls etc.)	Zonal in Guria OGZ; and Achara-Imereti OGZ	
5	**Turonian-Danian**	Carboniferous	200-1000	Fractured limestones and marls	Regional	
6	**Neokom-Aptian**	Carboniferous	up to 1000-1200	Limestones, dolomitized limestones and dolomites	Regional	
7	**Upper Jurassic**	Volcanogenic-Terrigenous	up to 2500	In upper part salt-bearing section; lower: sandy-clay sediments; lowest: volcanogenic rocks (albite basalts and dolerites)	Regional	+
8	**Upper Bajocian-Batonian**	Terrigenous	up to 1000	Alternation of shales and sandstones	Regional	+
9	Liassic	Terrigenous	up to 1000	shales with interlayers of sandstones and rear interlayers of limestones	Regional	+

Potential Shale Gas Formations of Georgia

Paleogene-Neogene

①Upper Miocene (Sarmatian)

② Oligocene-Lower Miocene (Maikopian Series)

Jurassic-Age

① Middle Jurassic (Aalenian-Bathonian)

② Lower Jurassic (Liassic)

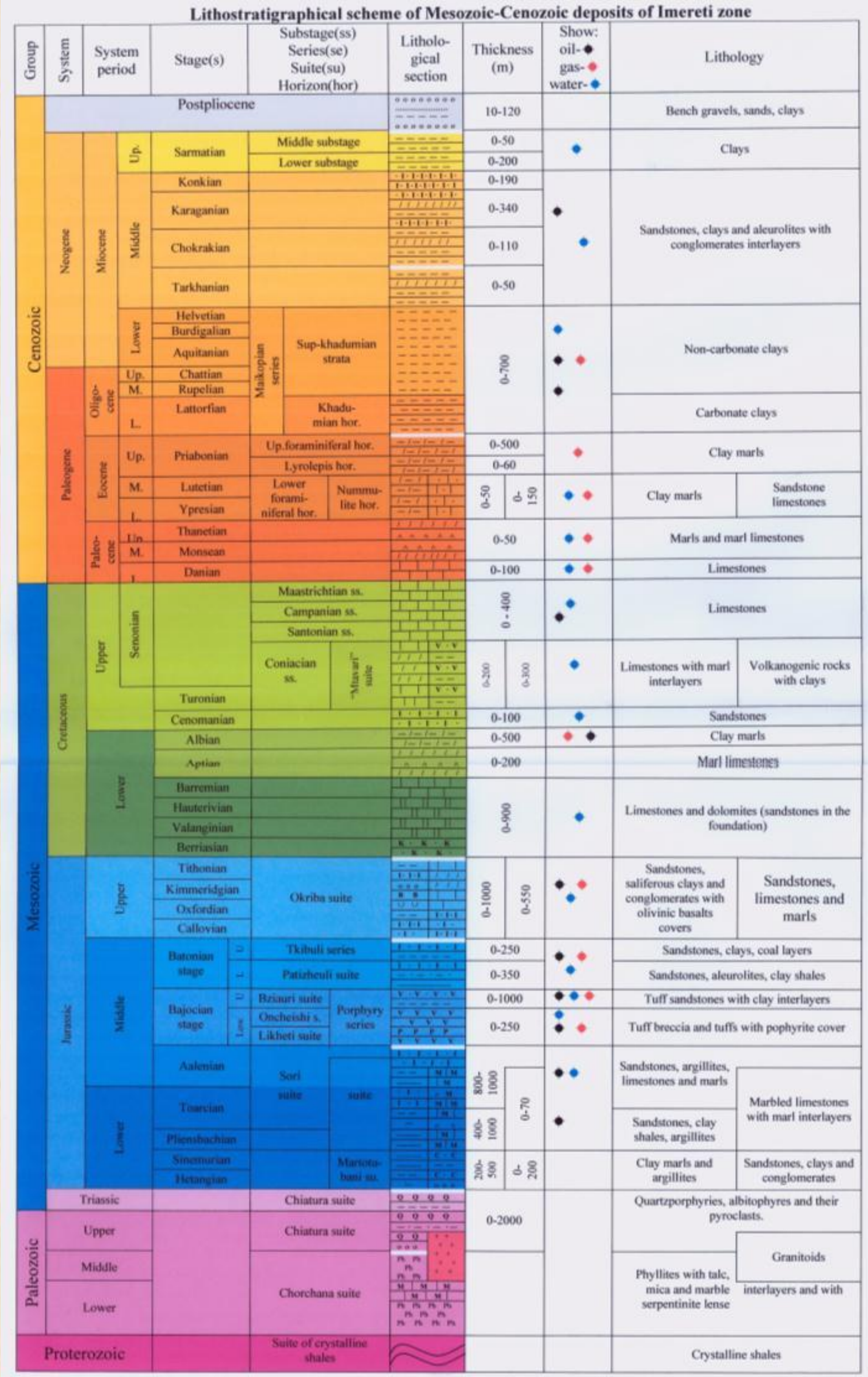
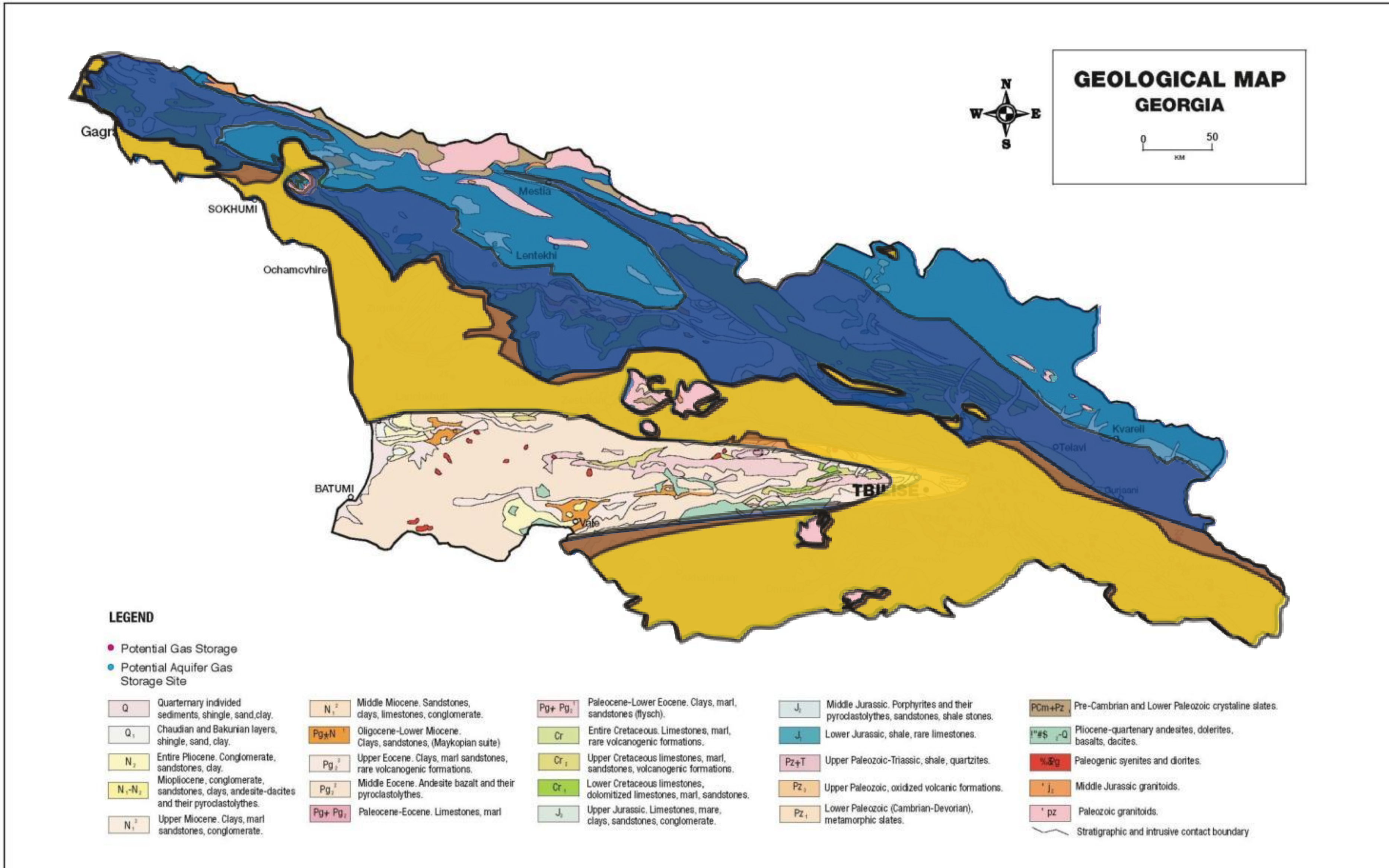
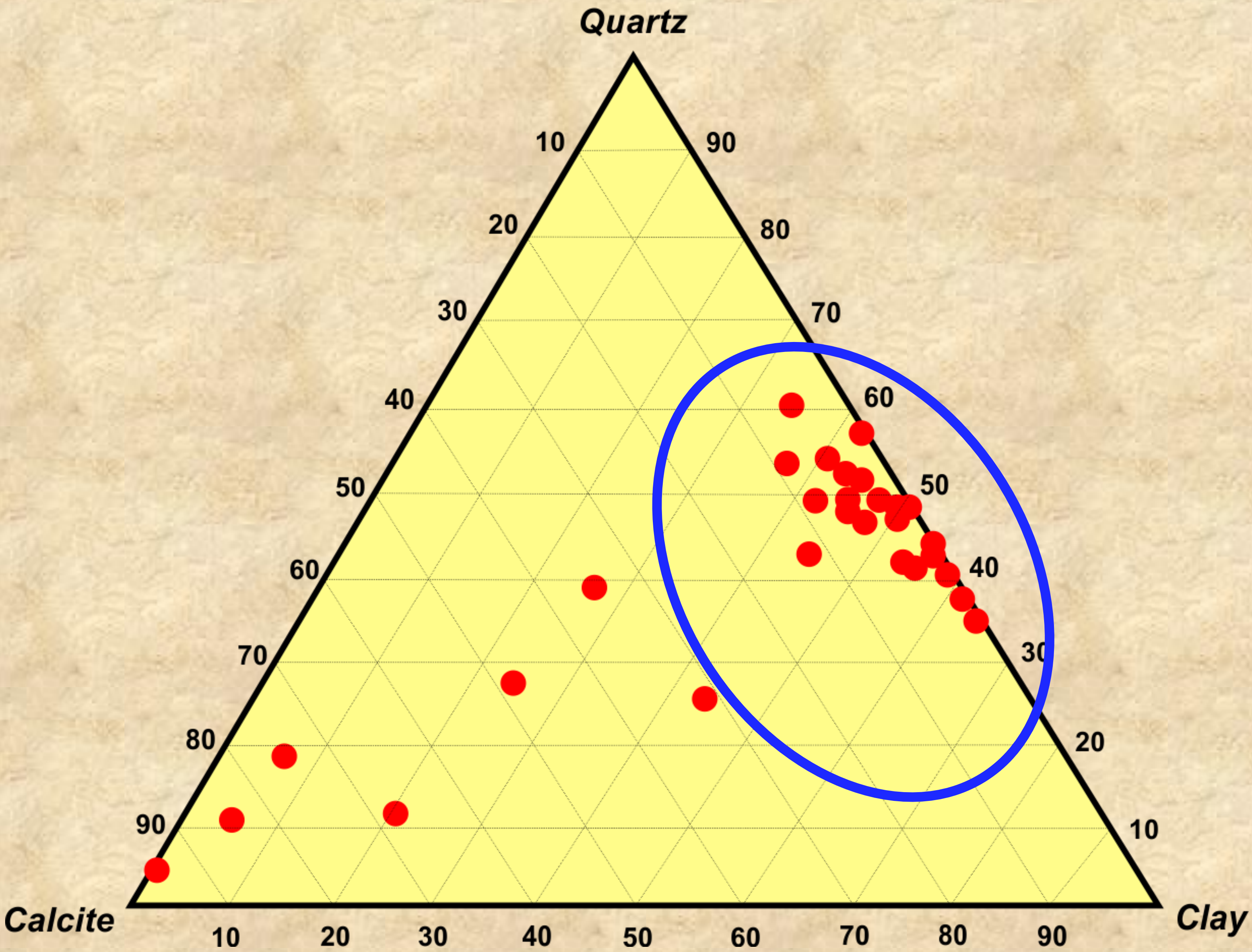


Table 1. Comparative Table of Identified Potential Gas Shale Formations in Georgia

Shale Formation	Depth min/max	Thickness min/max	Maturity	Distribution	Tectonics	Lithology	Gas & Oil Shows	Level of knowledge
Upper Miocene (Sarmatian)	0/3,000	300/3,000	matured	Zonal in: Kartli and South Kakheti, Guria and Abkhazeti-Samegrelo, OGZs; local in Rioni and Near-Tbilisi OGZs	Low	sandy-clay sediments with interlayers of conglomerates and oolithic limestones	Oil shows	Intermediate
Oligocene-Lower Miocene (Maikopian)	0/>5,000	700/2,500	matured	Regional	Intermediate	clays (shales) and sandy-clays sediments	Oil & Gas shows	Good
Middle Jurassic Aalenian-Bathonian	0/>9,000	400/1,300	matured	Regional	Tectonized with vertical and overturned folding, overthrusts bedding and thrust faults	alternation of shales and sandstones	Oil	Poor- intermediate
Lower Jurassic (Liassic)	0/>10,00 0	200/1,500	matured-over-matured	Regional	Same as above but more tectonized	shales and slates with interlayers of sandstones and rear interlayers of limestones	Oil shows, bitum en	Poor-intermediate

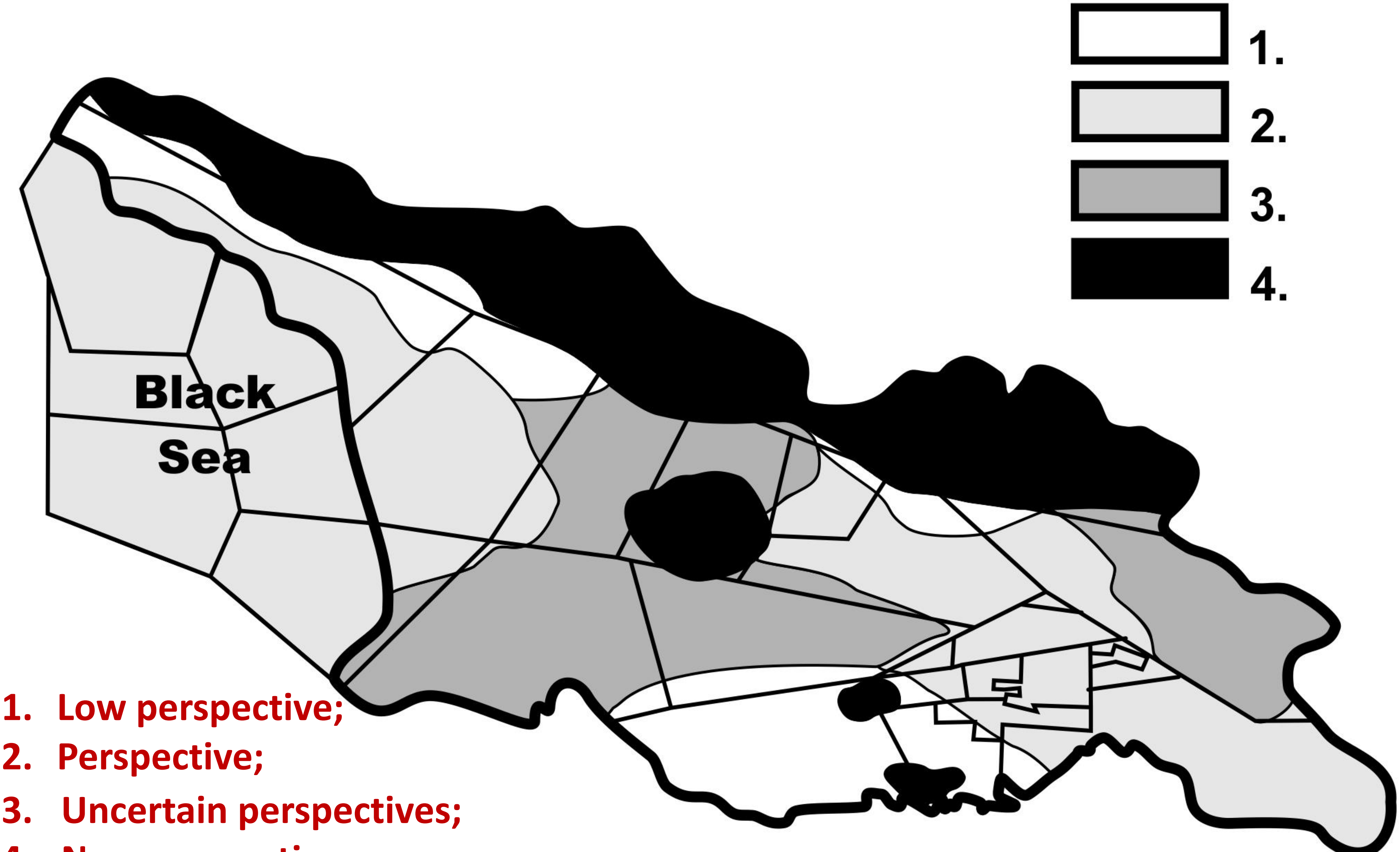

GEOLOGICAL MAP
GEORGIA
N
S
W
E
0
50
KM
Gagr
SOKHUMI
Ochamcvhire
BATUMI
Mestia
Lentekhi
Kvareli
Telavi
Vale
LEGEND
Potential Gas Storage
Potential Aquifer Gas Storage Site
Q Quarternary individed sediments, shingle, sand,clay.
Q1 Chaudian and Bakunian layers, shingle, sand, clay.
N2 Entire Pliocene. Conglomerate, sandstones, clay.
N1-N2 Miopliocene, conglomerate, sandstones, clays, andesite-dacites and their pyroclastolythes.
N1 Upper Miocene. Clays, marl sandstones, conglomerate.
N1 Middle Miocene. Sandstones, clays, limestones, conglomerate.
Pg+N Oligocene-Lower Miocene. Clays, sandstones, (Maykopian suite)
Pg2 Upper Eocene. Clays, marl sandstones, rare volcanogenic formations.
Pg2 Middle Eocene. Andesite bazalt and their pyroclastolythes.
Pg+ Pg2 Paleocene-Eocene. Limestones, marl
Pg+ Pg2 Paleocene-Lower Eocene. Clays, marl, sandstones (flysch).
Cr Entire Cretaceous. Limestones, marl, rare volcanogenic formations.
Cr2 Upper Cretaceous limestones, marl, sandstones, volcanogenic formations.
Cr1 Lower Cretaceous limestones, dolomitized limestones, marl, sandstones.
J3 Upper Jurassic. Limestones, mare, clays, sandstones, conglomerate.
J2 Middle Jurassic. Porphyrites and their pyroclastolythes, sandstones, shale stones.
J1 Lower Jurassic, shale, rare limestones.
Pz+T Upper Paleozoic-Triassic, shale, quartzites.
Pz3 Upper Paleozoic, oxidized volcanic formations.
Pz1 Lower Paleozoic (Cambrian-Devorian), metamorphic slates.
PCm+Pz Pre-Cambrian and Lower Paleozoic crystaline slates.
Pliocene-quartenary andesites, dolerites, basalts, dacites.
Paleogenic syenites and diorites.
Middle Jurassic granitoids.
pz Paleozoic granitoids.
Stratigraphic and intrusive contact boundary

According to the current Experience Shale gas and shale oil basins and formations that have very high clay content and/or have very high geologic complexity (e.g., thrusted and high stress) are assigned a high prospective area risk factor or as a rule, are excluded from the resource assessment



Quartz
Calcite
Clay
10
20
30
40
50
60
70
80
90

SHALE GAS & SHALE OIL PERSPECTIVE AREAS OF GEORGIA

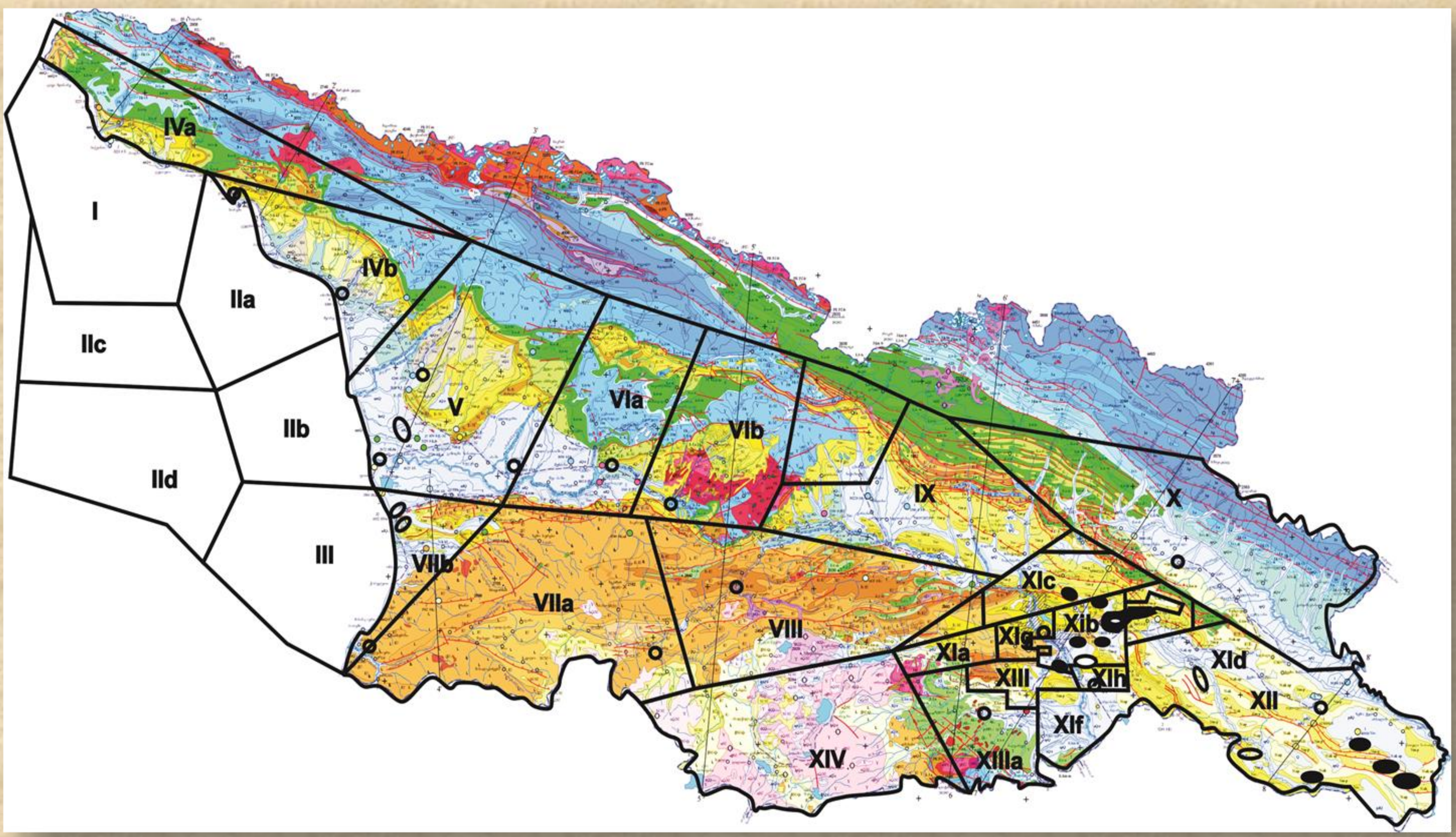


1. Low perspective;
2. Perspective;
3. Uncertain perspectives;
4. Non-perspective.

BLACK SEA OFFSHORE

Based on current knowledge on the Black Sea offshore geology we think that Georgian sector is quite promising from the unconventional hydrocarbons point of view. Particularly special attitude deserve Maikopian sequence (TOC ~1.8%) and Lower Cretaceous sediments (TOC ~1.9%) [Black Sea Azov Sea. Report #EB014, Simon Petroleum Technology, 1994)

OIL AND GAS LICENSE BLOCKS OF GEORGIA



OIL & GAS EXPLORATION & TRANSPORTATION

CONCLUSIONS

The capacity of Georgian sedimentary section to generate hydrocarbons is apparent from the occurrence of oil and gas fields, subsurface oil and gas shows, surface oil seeps, and analyses of organic matter from potential source rocks.

The primary candidate Gas Shale formations in Georgia are: i) Upper Miocene (Sarmatian); ii) Oligocene-Lower Miocene (Maikopian); iii) Middle Jurassic Aalenian-Bathonian-age shale sediments, and iv) Lower Jurassic (Liassic).

These sediments are present at varying depths over the northern and eastern one-third of Georgia.

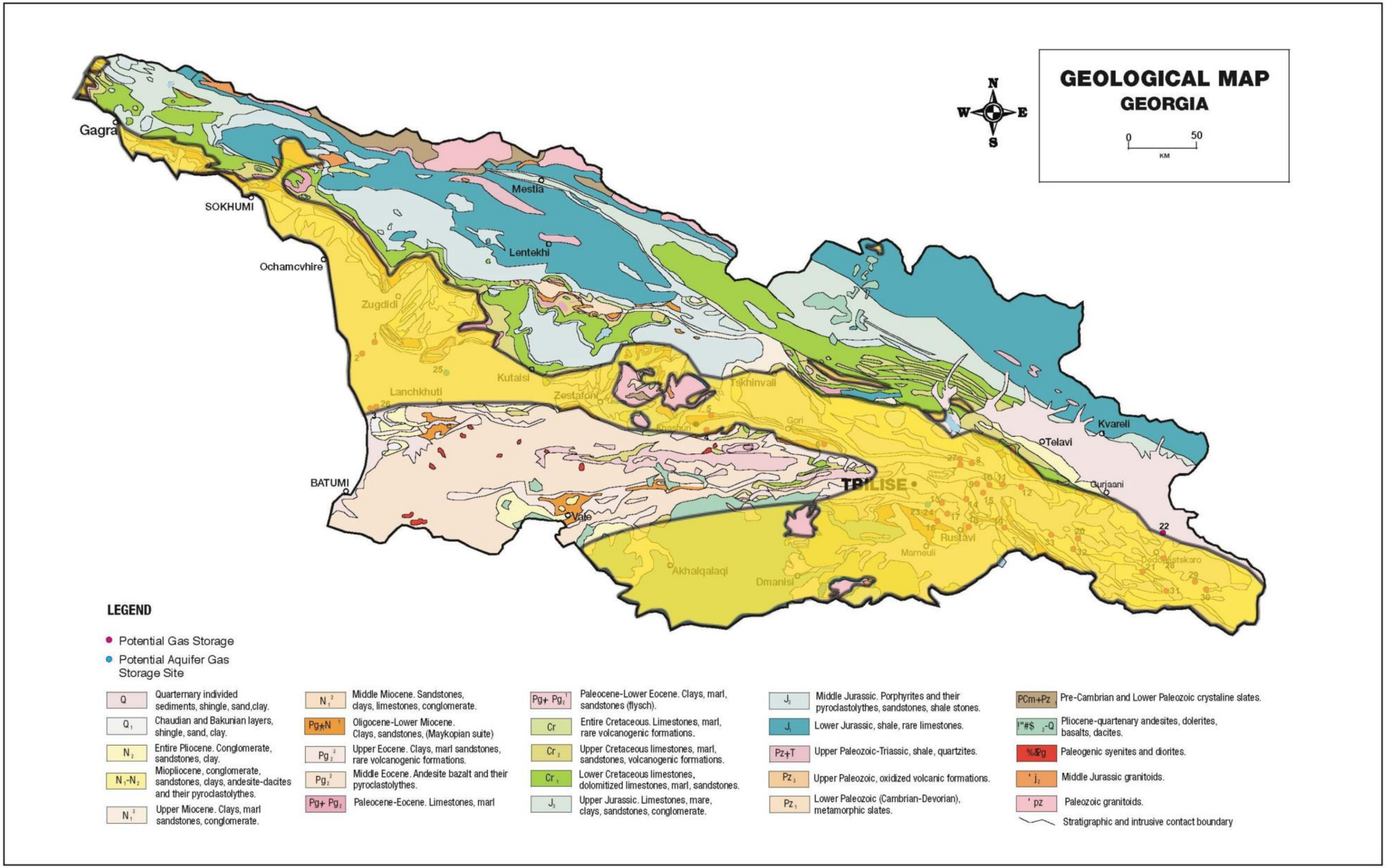
The Sarmatian, Maikopian, and Liassic are known to be kerogen rich from surface oil seeps and oil and gas shows in wells. The Aalenian-Bathonian-age shale sediments show evidence of oil and gas in well logs. The thermal maturity within these formations tends toward oil versus natural gas and is favorable for shale gas.

The resource potential of Georgian Shale Gas and Shale Oil can classified as considerable and are adequate to recommend implementing further big scale assessment of Shale Gas and Shale Oil in Georgia.

Numerous gas and oil shows reported by various license block owners and from earlier periods, indicate a high probability of gas and/or oil presence in these shale formations. As in many cases the main concern is the potential scale and the cost of its production.

There is a host of geology information accumulated in different times at different institutions that needs to be consolidated and digitized for narrowing the range of shale gas exploration.

A comprehensive gas strategy needs to be developed along with shale gas exploration in order to guide the government actions for promotion of domestic gas resources.



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Gori
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Kvareli
Telavi
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Stratigraphic and intrusive contact boundary

Development of Shale Gas Is Problematic

RESOURCE ACCESSMENT DIFFICULT

MAJOR DATA ISSUES

① Little to no Data
  - ① Typically Overlooked by Oil & Gas Companies
  - ② Maybe Only Recorded as a Gas Show on a Log

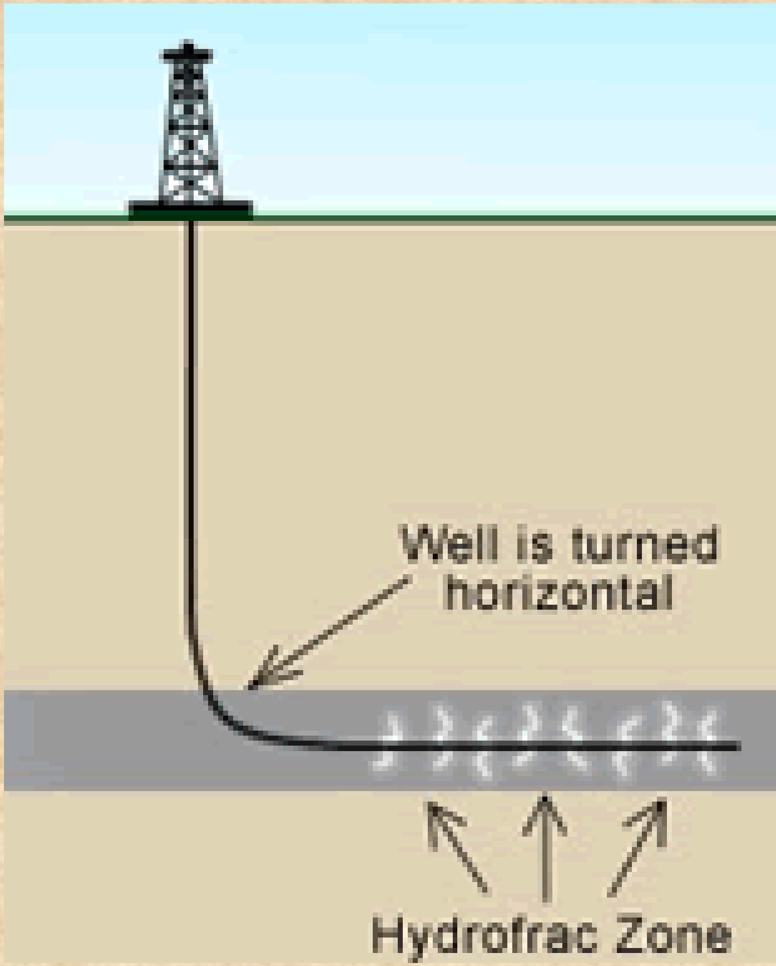
② Data Not Easily Accessible
  - ① Held By Multiple Agencies
  - ② Held by License Block Operators

③ Data Never Been Analyzed for Shale Gas Development
  - ① Economic Incentive Not Adequate in Lieu of Trading Oil & Gas Plays

ADVANCE TECHNOLOGY NECESSARY TO ACCESS & DEVELOP RESOURCE

① Complex Exploratory Drilling & Development
  - ① Horizontal Drilling
  - ② Well Depths
  - ③ Over Pressured Environment

② Unique & Proprietary Logging Analysis Tools & Mythology
  - ① Special Logging Tools
  - ② Complex Hydro Fracturing Required



General Approach to Development

- Develop the play concept, lease the core
- Partner up to drill a science or a proof-of-concept well
  - demonstrate presence of mobile gas
  - magnitude of gas in place resource
  - some minimum level of deliverability after frac
- Development will require horizontal drlg and fracing. Gets $$$$$ quickly. Few of these plays work on a low cost, vertical well basis.

Approach to Shale Gas & Shale Oil In Georgia

Develop a Unified Geological Data Base

- GIS System of Well Logs (only 3,000 well logs)
- Digital 3D Maps of Potential SG Formations

Develop a SG Resource Analysis Program with Licensees

- Detailed Prospect Mapping by Blocks
- Prepare Prospect Development Plan by Blocks

Pilot Exploratory Drilling & Test Program

- Drill Pilot Exploratory Well
- Produce Gas or Oil from Pilot Well

Design & Implement SG Program

- Define Prospects
- Develop Funding Program
- Implement Program

FURTHER STEPS

Successful development of Shale Gas and Shale Oil in Georgia will depend on resolving of following issues:

- **Identification and description of Shale Gas and Shale Oil resources;**
- **Compiling of 3D digital map of possible Gas and Oil shales**
- **Modeling and study of Gas bearing reservoirs (formations)**
- **Identification of well drilling and well completion technologies;**
- **Price and volume of extracted gas**
- **Elaboration of regulations**
- **Environmental issues: emissions, waste and water management, land use etc.**

Thank you very much!
and
Questions?