Pôvod a geologicko – ekonomické aspekty ťažby ropy

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Česko-slovenský po-konferenčny seminár
14.6. 2011

Prednáška

1. Vznik ropy – pôvod ropy
2. Hodnotenie zásob a svetové zásoby
3. Vyčerpanie zásob

Organogénna teória vzniku ropy

- **Geológia – skúma históriu Zeme**
- **Geologické – geochemické, paleontologické, paleogeografické, paleoklimatologické a i. argumenty – 70-te roky 20. storočia**

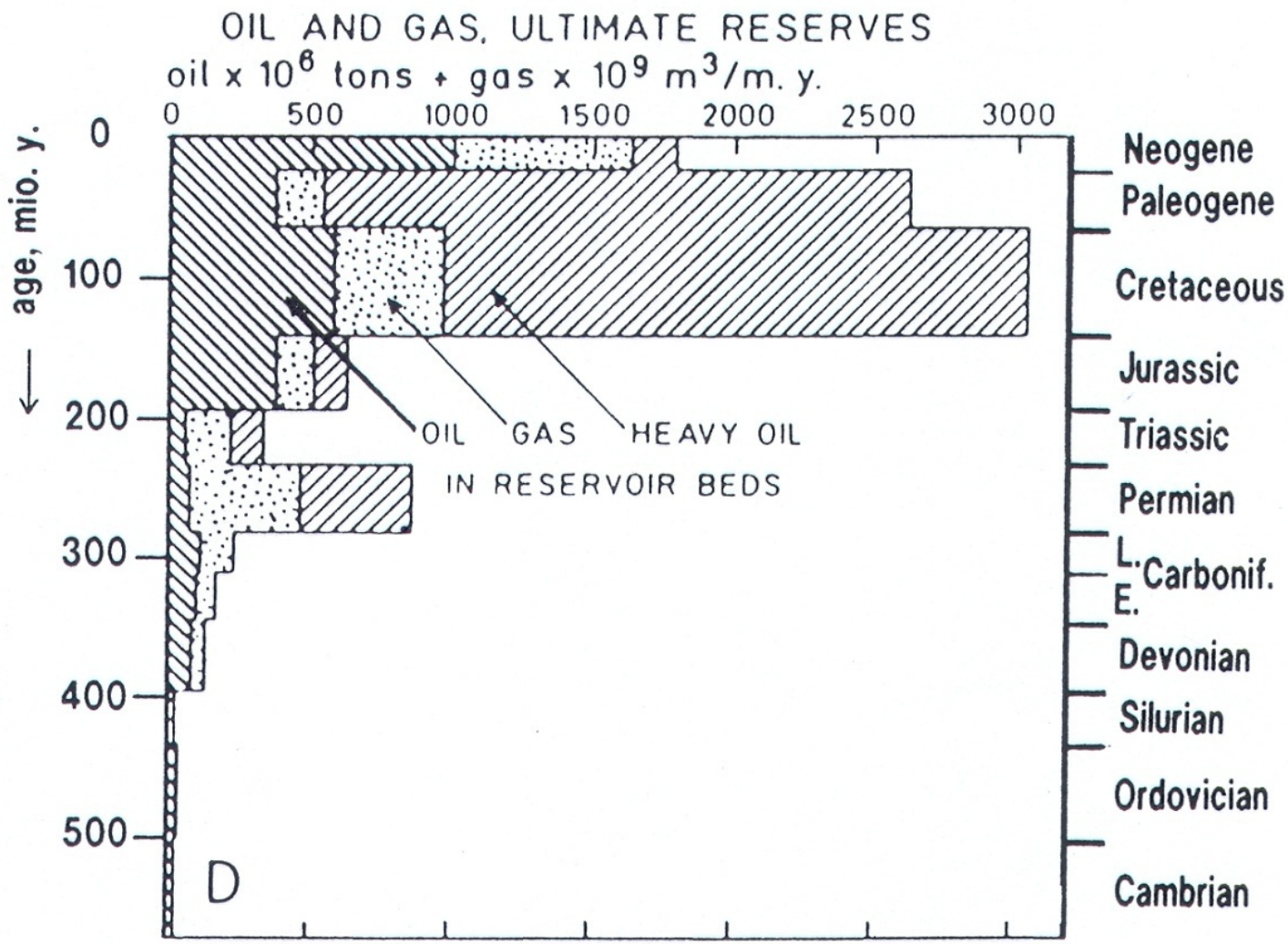
Ropa sa nachádza v sedimentárnych súvrstviach z rôzneho geologického obdobia (najmä posledných 500 miliónov rokov) a je v nich možné preukázať spojitosť s procesom akumulácie a transformácie organickej hmoty

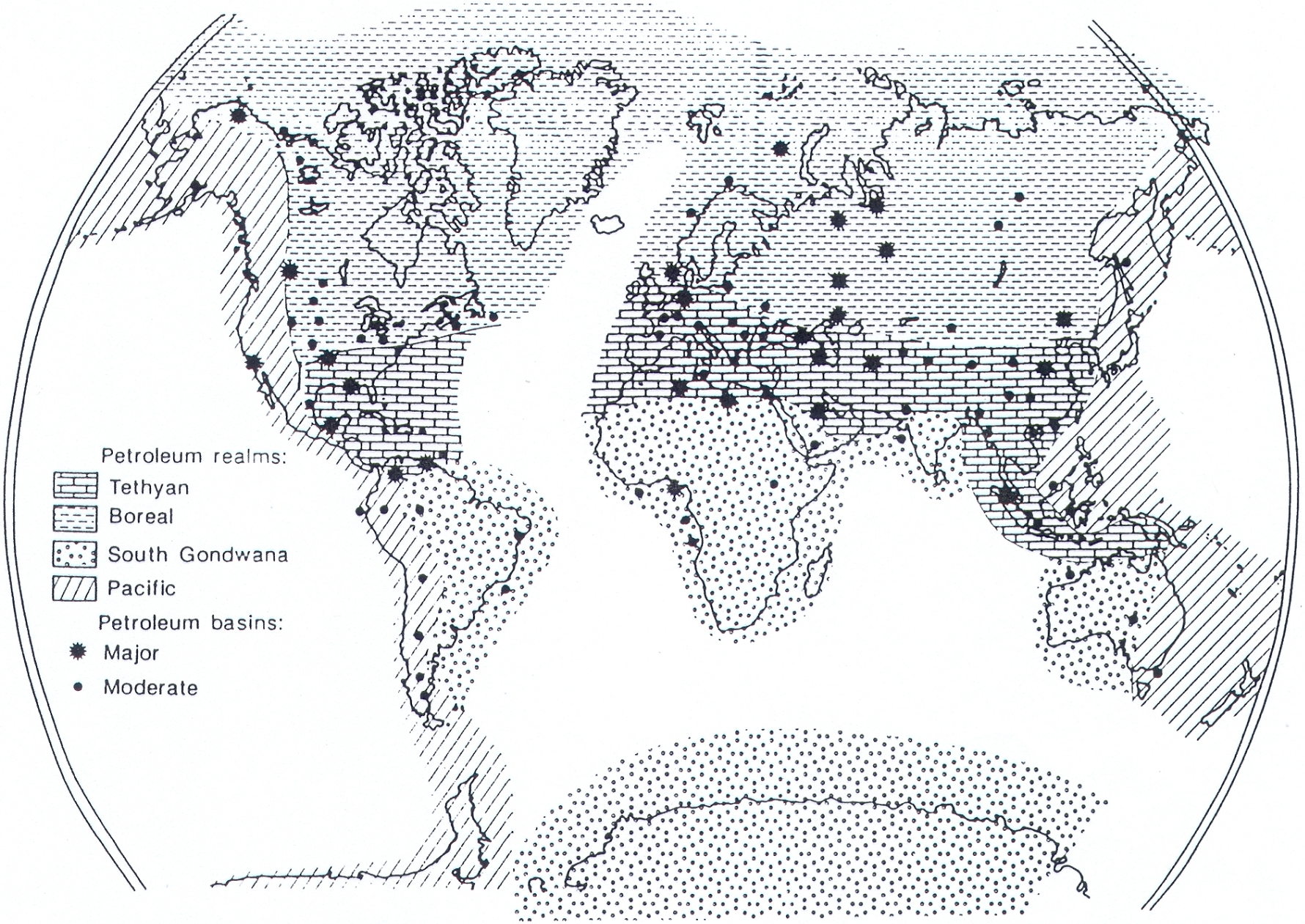
Koncepcia transformácie organickej hmoty na ropu (generačné – produktívne panvy), migrácia a tvorba ložísk (primárna a sekundárna migrácia), je empiricky overovaná – potvrdzovaná pri úspešnom vyhľadávaní a ťažbe existujúcich ložísk

Ropa a ostatné fosílne palivá (uhlie, uhoľné bridlice, plyn) sú najväčšie akumulácie fosílneho organického uhlíka, čo je možné priamo preukázať dostupnými geochemickými metódami

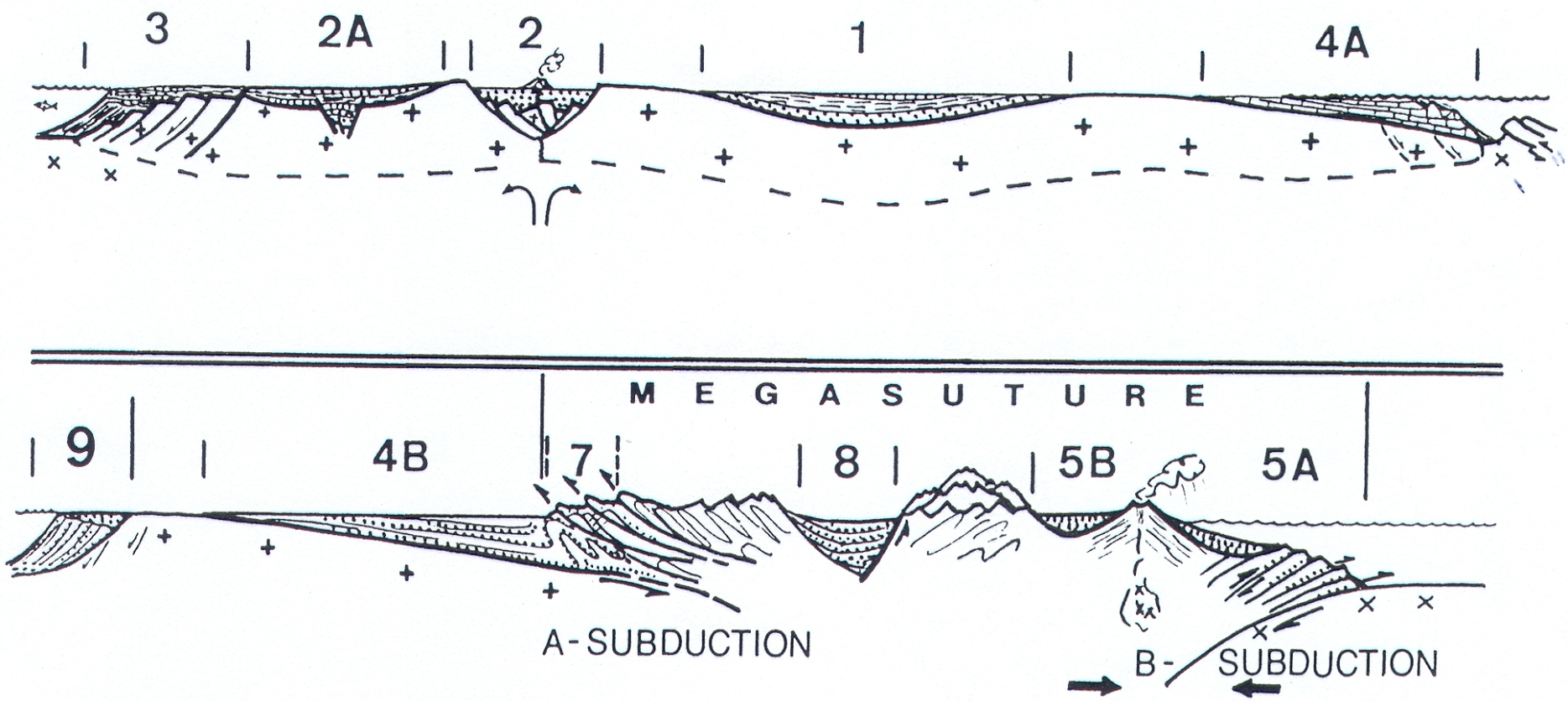
Ropa sa nachádza v geologických štruktúrach vo veľkom množstve, veľká časť bola degradovaná v dôsledku geologických procesov (zvetrávanie, tektonické procesy – stopy ropy je možné identifikovať) a je to v súlade s globálnym geochemickým cyklom uhlíka

Distribúcia ropy v geologickom čase



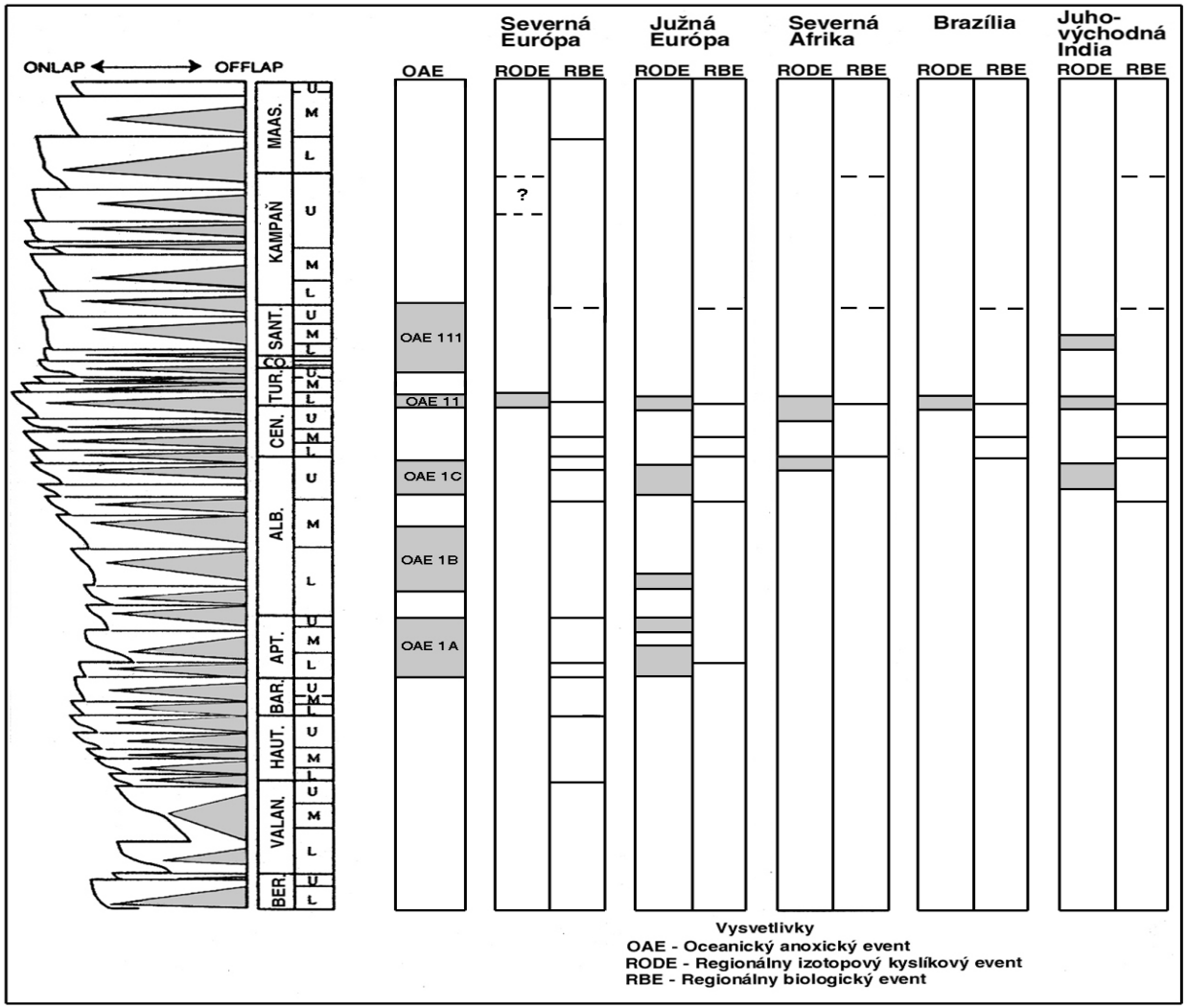

Petroleum realms:
Tethyan
Boreal
South Gondwana
Pacific
Petroleum basins:
Major
Moderate

Pravdepodobnosť tvorby ropy v sedimentárnych panvách



1.Materské horniny – ropa sa tvorí z organickej hmoty v horninách : akumulácia org. hmoty sa uskutočnila len v určitých podmienkach/obdobiach

„Black shales“ - sedimentoch v kriedovom období – tzv. oceanické anoxické eventy (Weissert a Chanell 1989),



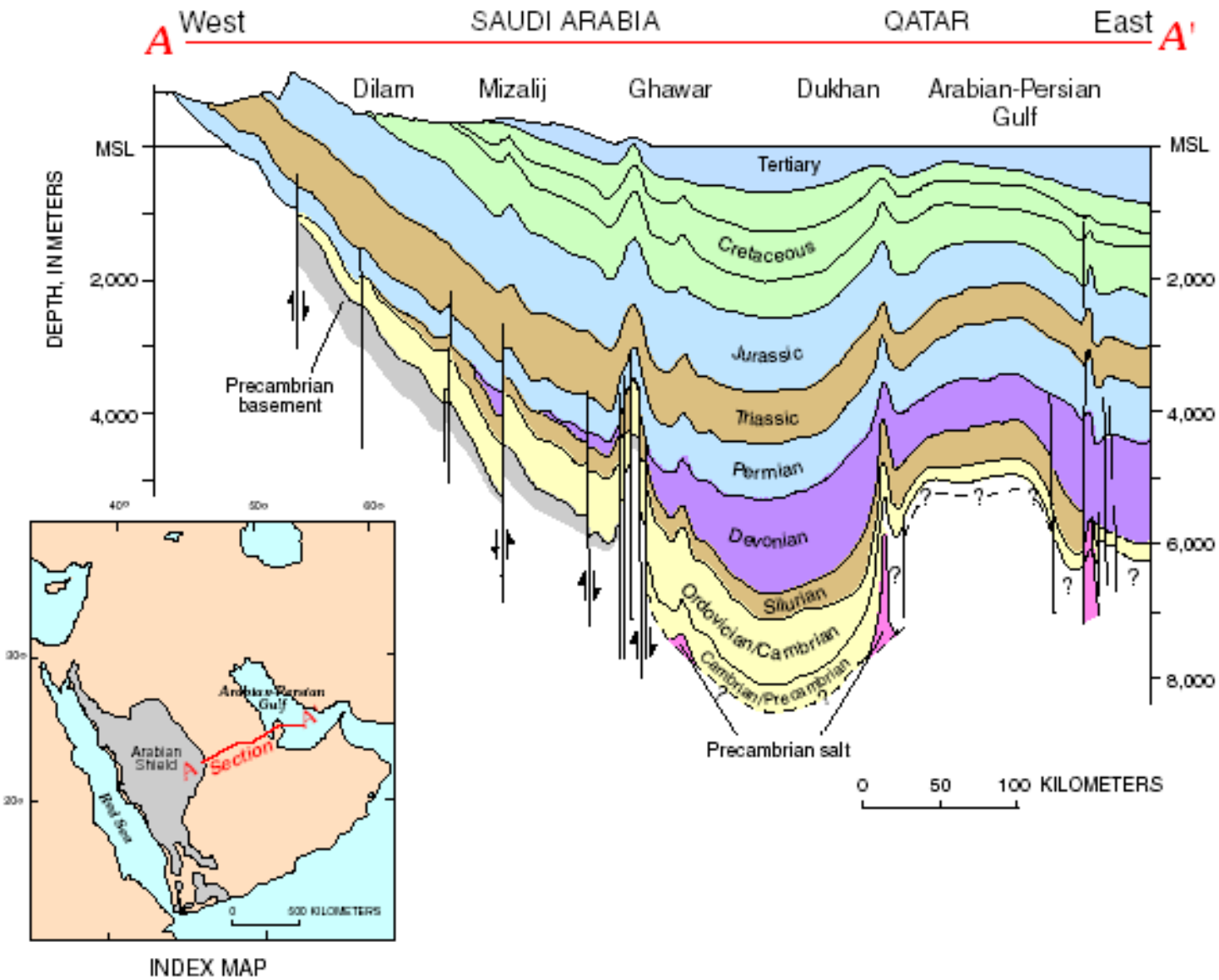


Figure 9. Geologic cross section across Saudi Arabia and Qatar from Arabian Shield to Arabian-Persian Gulf showing basement reverse faults and Precambrian (Infracambrian) salt. Modified from Alsharhan and Nairn (1997) and Konert and others (2001). Barbs show relative movement on faults.

Unit	Name	Code
Region	Middle East and North Africa	2
Province	Greater Ghawar Uplift	2021
Total Petroleum Systems	Central Arabia Qusaiba-Paleozoic	202101
	Arabian Sub-Basin Tuwaiq/Hanifa-Arab	202102
Assessment Units	Central Arch Horst-Block Anticlinal Oil and Gas	20210101
	North Gulf Salt Basin Structural Gas	20210102
	Horst-Block Anticlinal Oil	20210201
	Salt-Involved Structural Oil	20210202

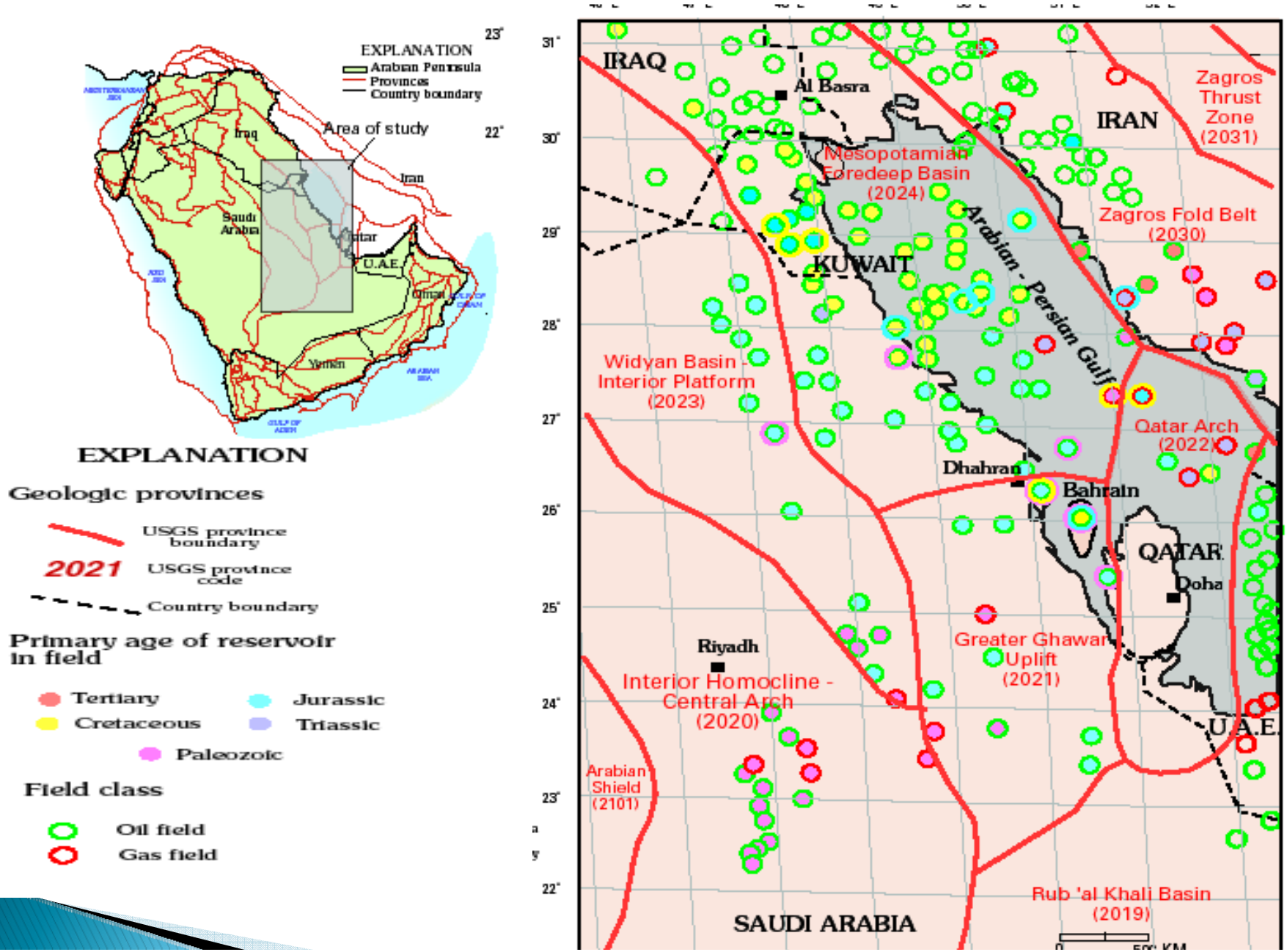
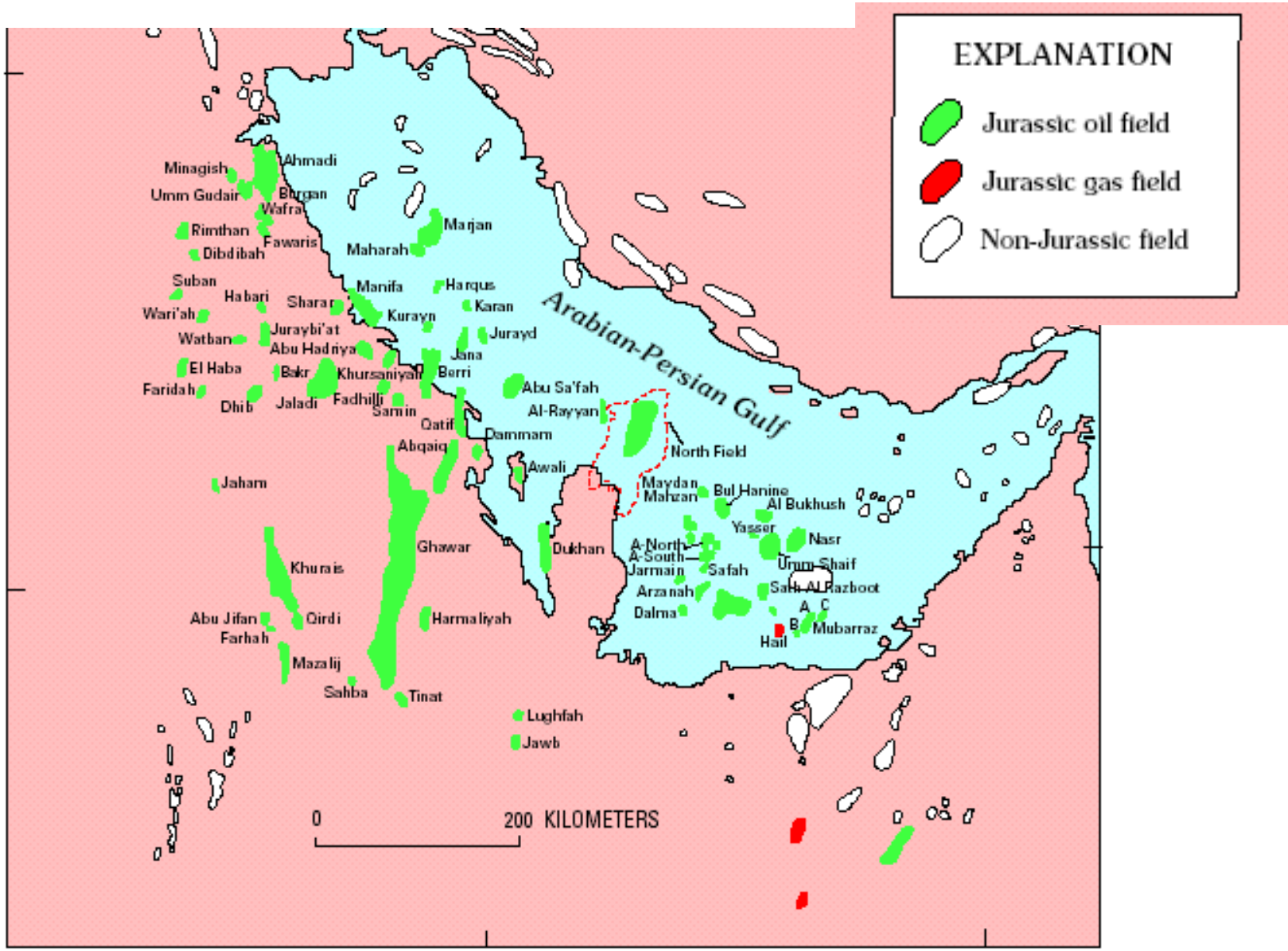


Figure 2. USGS geologic provinces of central Saudi Arabia and northern Arabian-Persian Gulf, oil and gas field centerpoints, and primary age of reservoir for each field. U.A.E., United Arab Emirates.



ure 32. Oil and gas fields of the Arabian-Persian Gulf region with reservoirs in Jurassic age rocks. Modified from Husseini (1997).

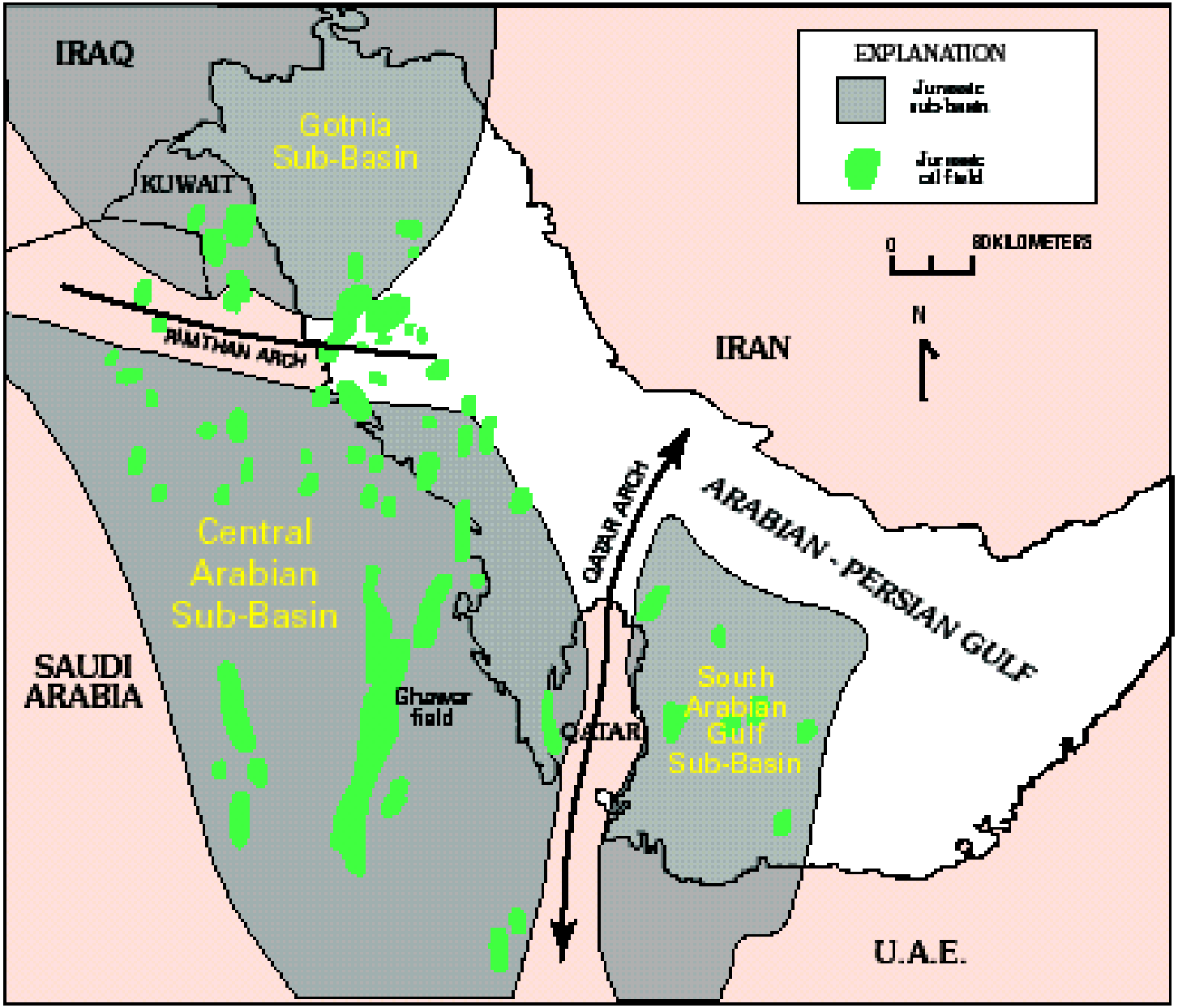


Figure 4. Jurassic intraplatform sub-basins of Arabian-Persian Gulf region. Modified from Murris (1980), Alsharhan and Kendall (1986), Alsharhan and Magara (1994), and Grabowski and Norton (1995). U.A.E., United Arab Emirates.

Prekrytie / pochovanie do hĺbky = rast teploty a tlaku – limitujúci faktor tvorby a zachovania „organogénnych“ látok

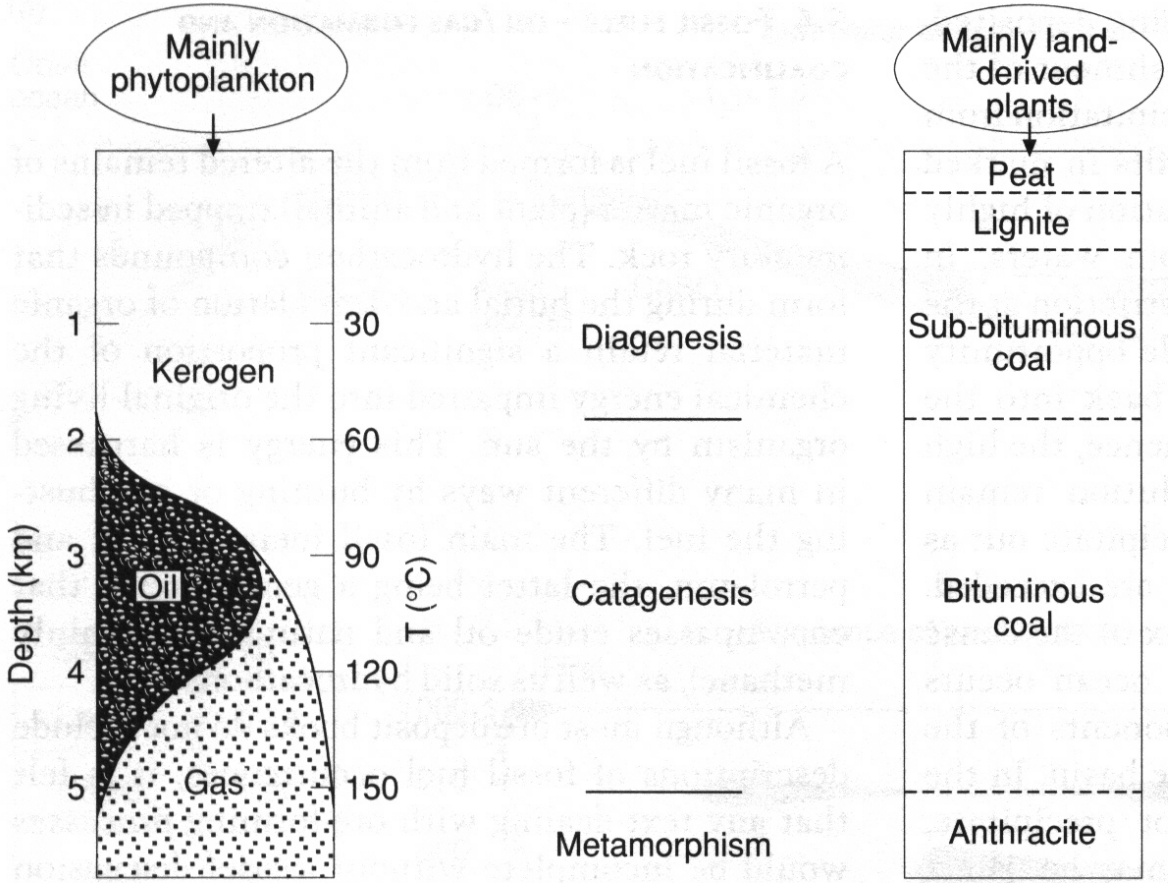
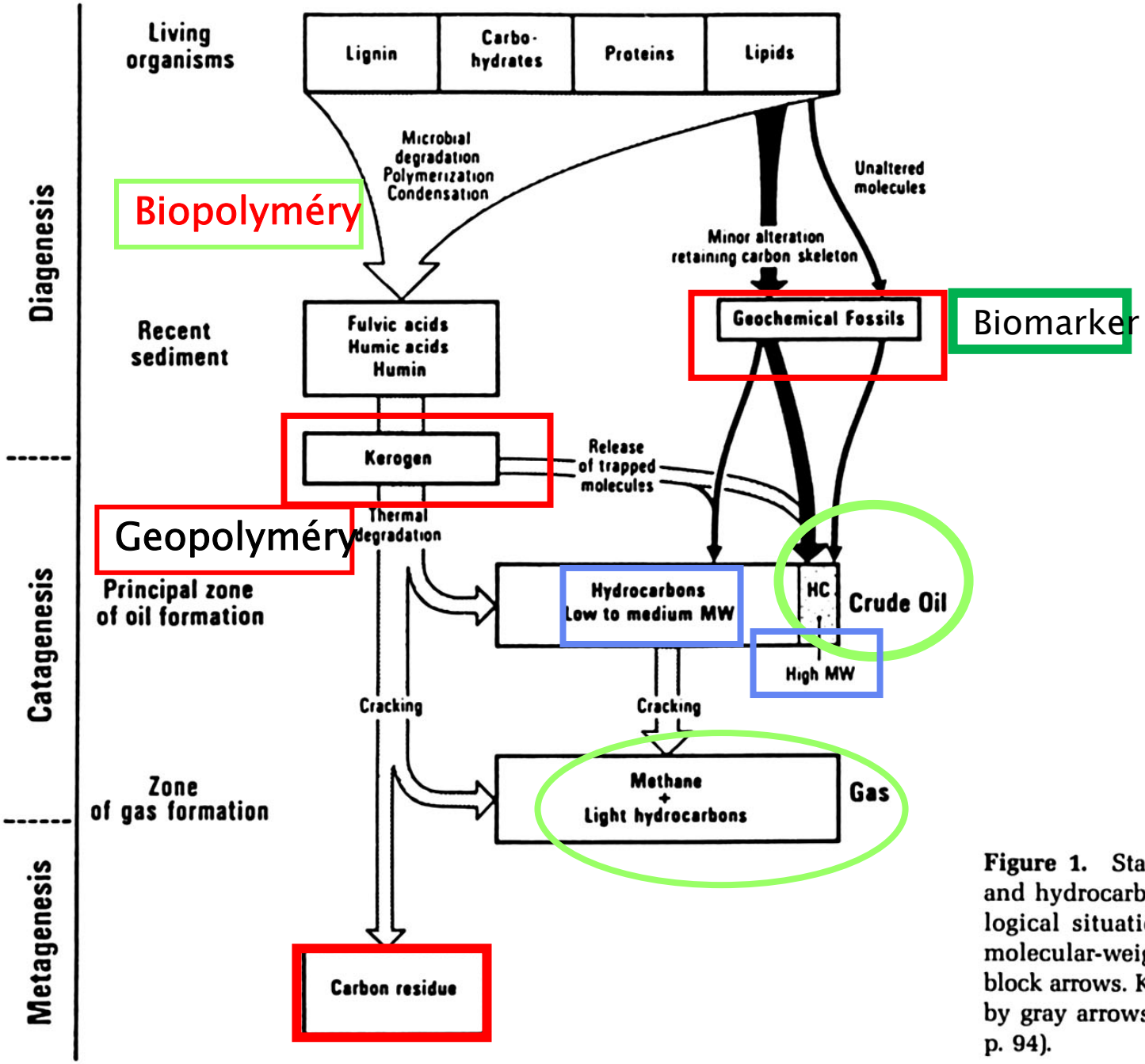


Figure 5.26 Simplified scheme illustrating the formation of oil, gas, and coal by the progressive burial of different types of mainly vegetative matter (after Hunt, 1979).



Nárast T, p, pochovanie v geologickom čase

Figure 1. Stages of kerogen transformatio and hydrocarbon formation pathways in ge logical situations. Direct inheritage of lov molecular-weight compounds is indicated b block arrows. Kerogen transformation is show by gray arrows (from Tissot and Welte, 198 p. 94).

Anorganické teórie

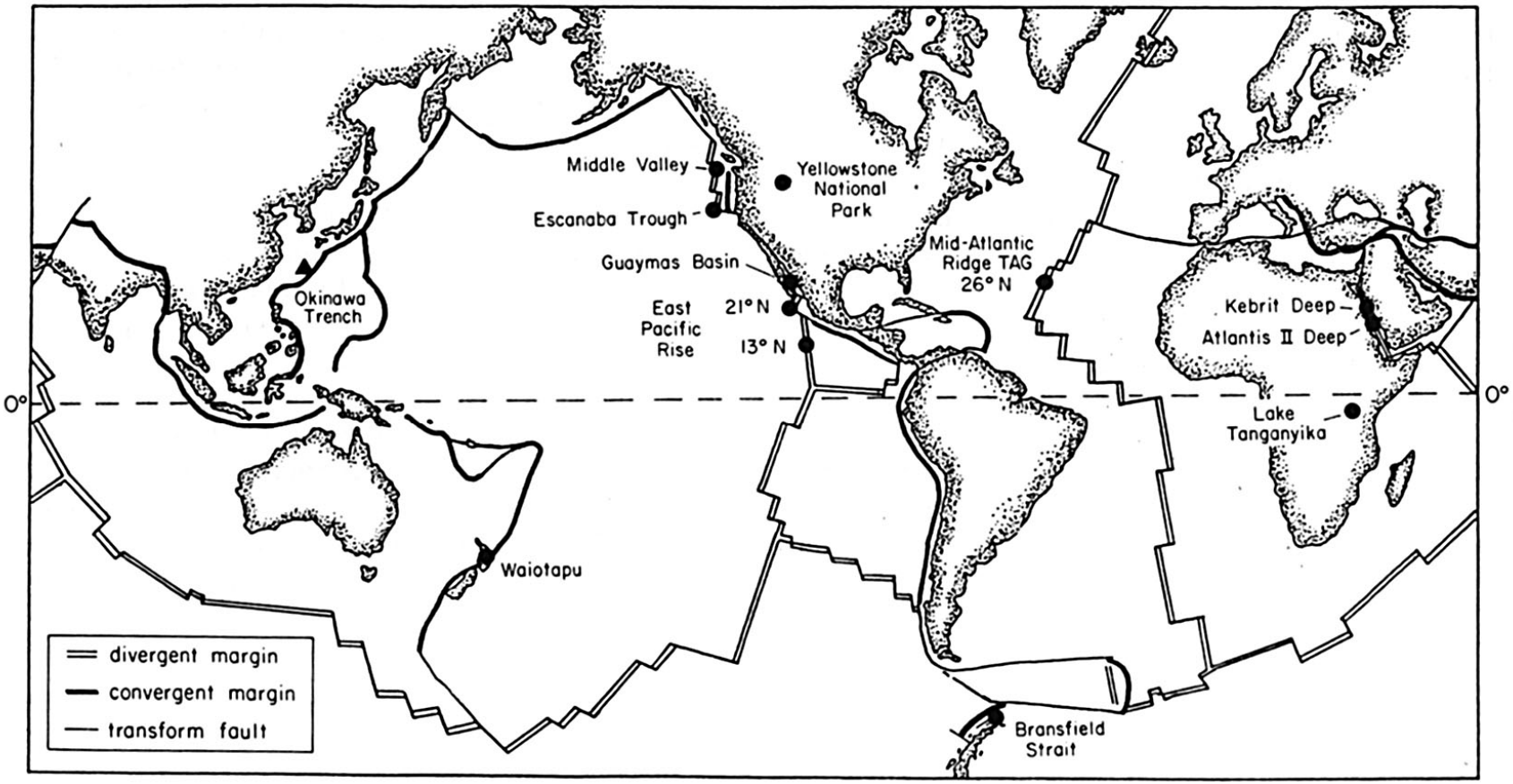


Figure 1. General location map of the hydrothermal vent fields discussed in this chapter with the sketched global tectonics.

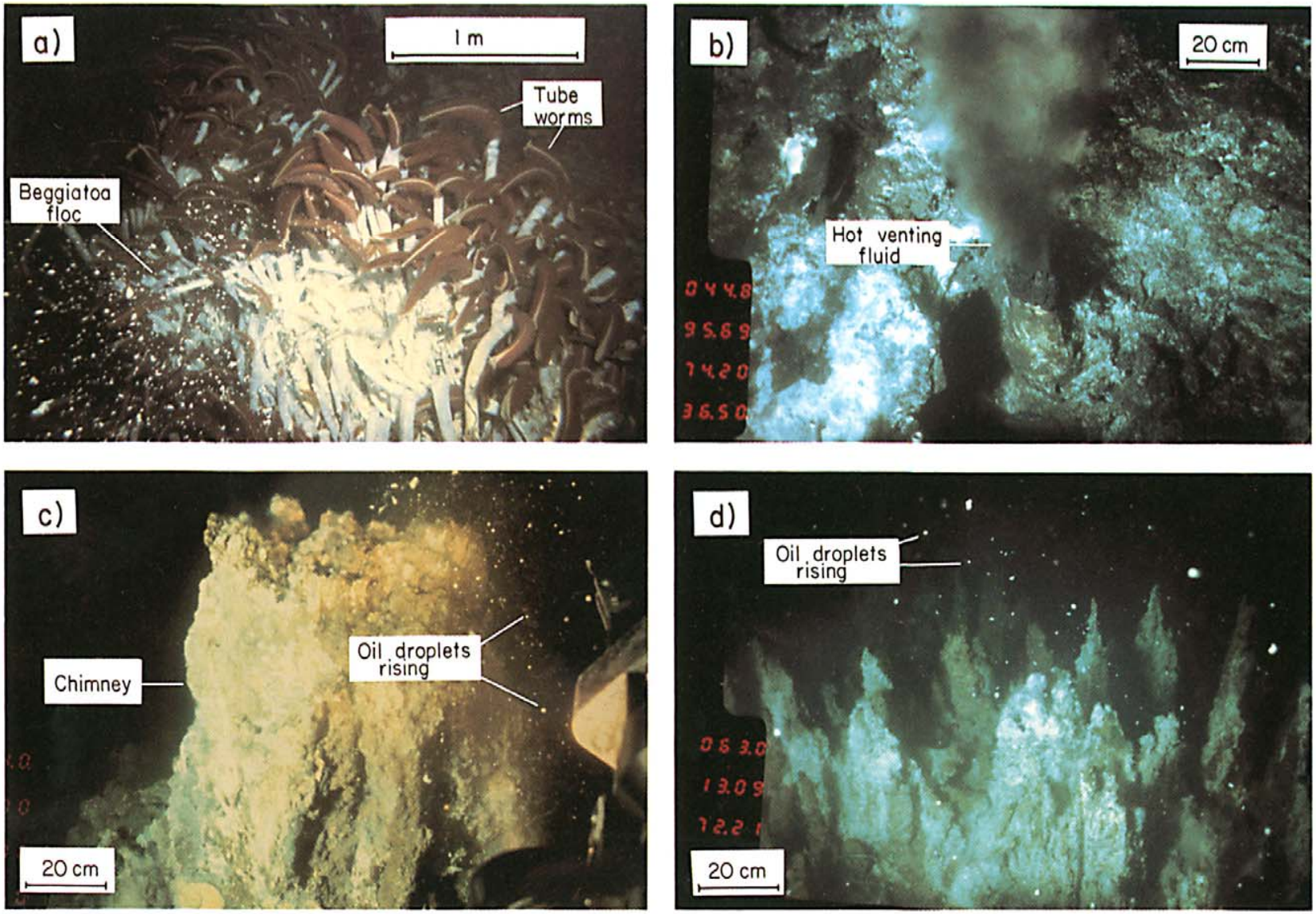


Figure 2. Photographs of examples of Guaymas Basin vent systems: (a) mound macrofauna (tube worms and beggiatoa floc); (b) vent discharging hot fluid, (c) petroleum rising from base of chimney, (d) petroleum rising from top of mound with small chimneys.

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Behavior of polycyclic aromatic hydrocarbons at impact shock: Its implication for survival of organic materials delivered to the early Earth

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Abstract—Polycyclic aromatic hydrocarbons (PAHs) with a hydrous or an unhydrous mineral matrix were impacted and analyzed, to study the behavior of PAHs against shock. Results of the shock experiments suggested that volatiles discharged from the hydrous mineral did not influence the behavior of PAHs against shock. The shocked samples contained unreacted starting PAHs, soot-like materials insoluble in dichloromethane, and secondarily formed PAHs with molecular weights ranging from 128 to 404. Approximately 95% of starting PAHs decomposed at ~30 GPa and the dominant product was the soot-like materials. Formation mechanisms of the shock products were explained by reaction processes under static high pressure-temperature conditions (e.g., carbonization, radical addition reaction, ring cross linking, and methylation).

We applied these results to estimate the survival degree of organic matter delivered by carbonaceous asteroids against their impact pressures at the accretion stage of early Earth. If we use a simplified homogeneous accretion model without atmosphere to represent the stage, the radius of Earth causing 30 GPa, the pressure at which PAHs almost decompose, was calculated as 2270 km (4.0 km s^{-1} of impact velocity) for the impact of carbonaceous asteroids. In the case of impactors striking not land but oceans on the early Earth, the impact velocity for the decomposition of PAHs was estimated to be 6.0 km s^{-1}. These impact velocities should have been commonly realized on the early Earth, due to the airburst and the aerobreak of impactors in the dense atmosphere. The early Earth should have been a favorable environment for obtaining and maintaining a large quantity of prebiotic organic materials leading to life. *Copyright © 2005 Elsevier Ltd*

BGR (Bundesanstalt für Geowissenschaften und Rohstoffe)

Neobnoviteľné energetické suroviny

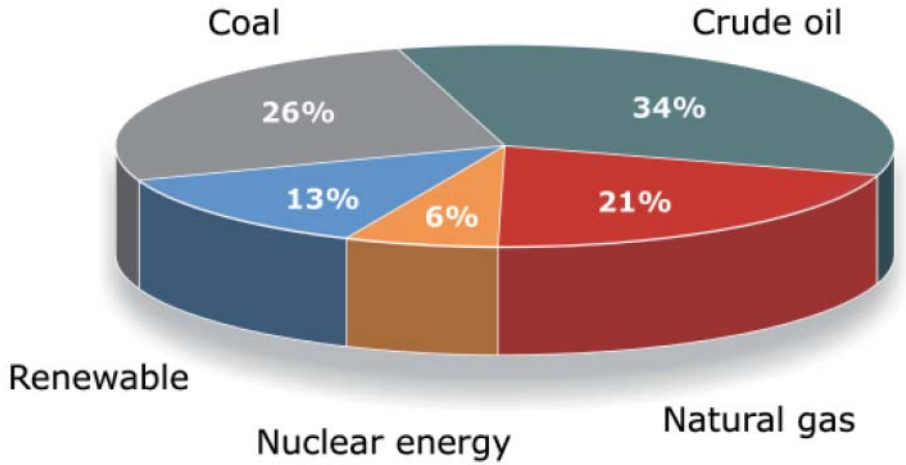
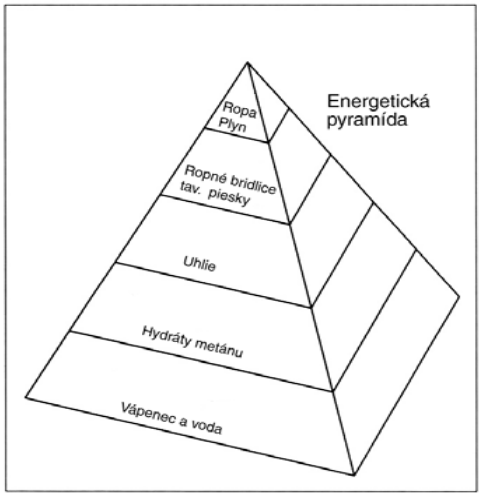
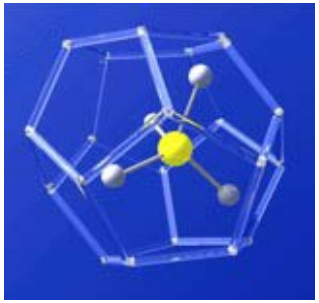


Figure 2.1: Proportion of the individual energy resources on the total primary energy supply in 2006 worldwide (IEA, 2008).

Ťažíme najkvalitnejšie HC

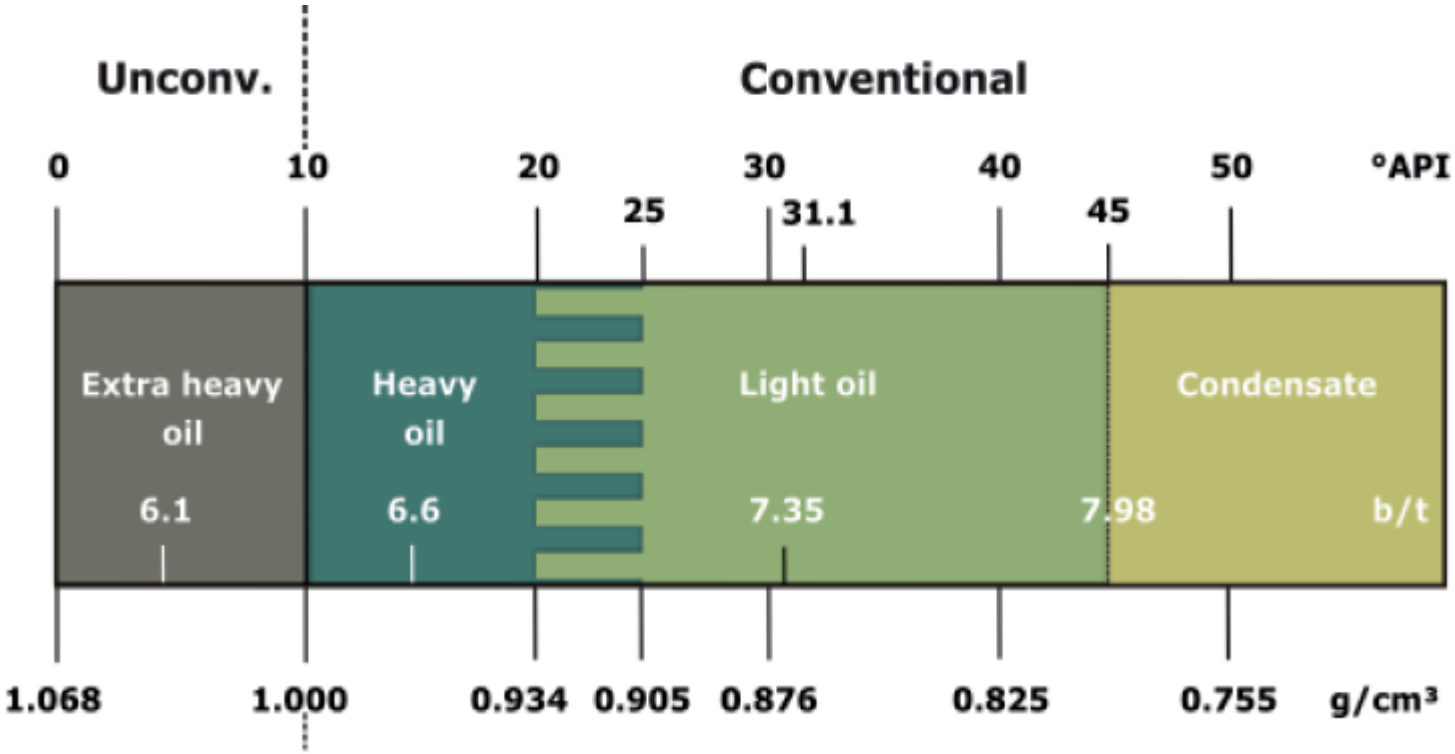




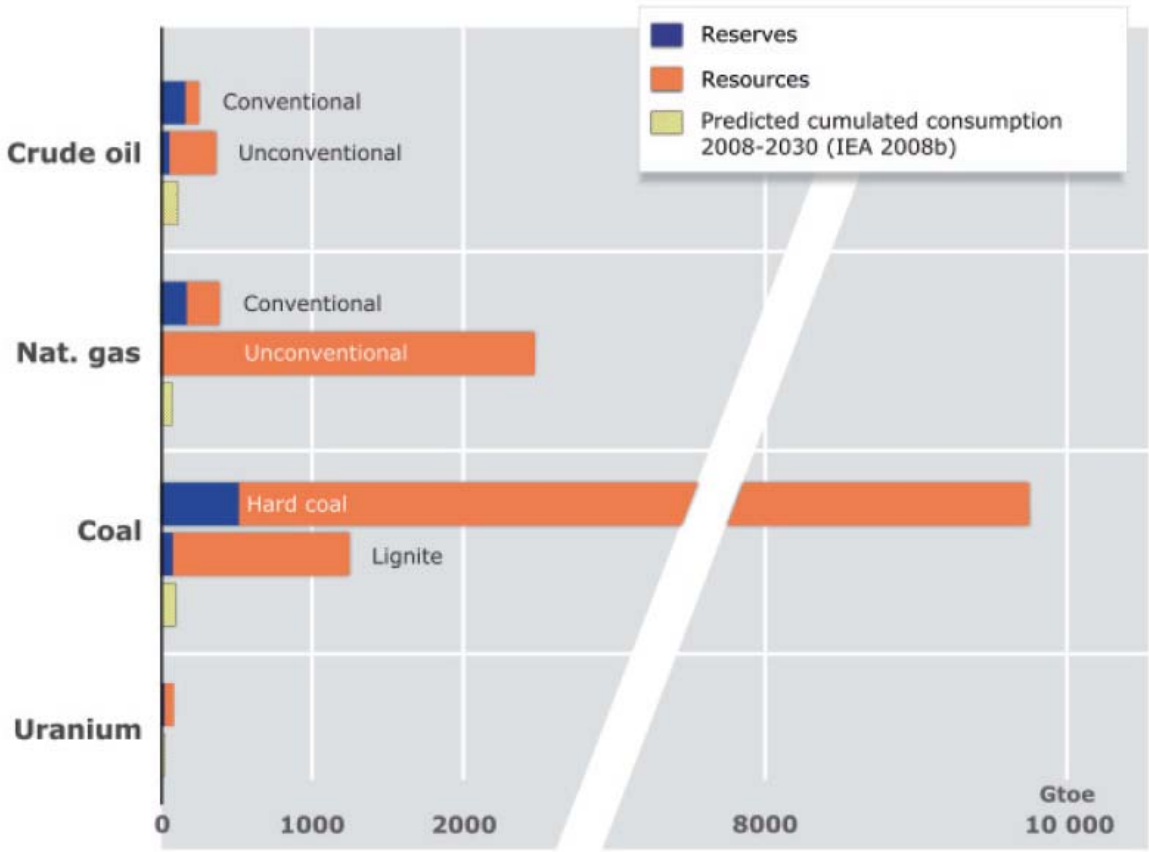
Tradičné a netradičné fosílne a iné palivá

Crude oil	Natural gas	Coal	Nuclear fuel	
Light oil Heavy oil Condensate	Free nat. gas Associated gas	Hard coal Lignite	Uranium in ore deposits Thorium	conven-tional
Extra-heavy oil Bitumen (Oil sand) Shale oil (Oil shale)	Tight gas Shale gas Coalbed methane Aquifer gas Gas hydrate		Phosphates Granites Seawater	unconv.

Ropa **je zmes uhľovodíkov a** podľa ich kvantitatívneho zastúpenia sa odvíjajú vlastnosti ropy (hodnotené na povrchu, po vyťažení)
napr. hustota : klasifikácia podľa hustoty



igure 2.3: Classification of crude oil according to its density.



.3: Supply situation (reserves and resources) of non-renewable energy resources in comparison with a demand scenario by the IEA (2008) to 2030.

Zásoby energetických surovín

- Všeobecne zásoby nie sú konečné – aktualizácia zásob
- – informácie geologické a vedeckých poznatkov (G– parameter/os)
- – pretože ide o strategické suroviny – ekonomické a politické vplyvy na hodnotenie zásob

Celkové zásoby surovín

- overené zásoby (bilančné a nebilančné – **Reserves**)
- neoverených zásob **(Resources**).
- „Kumulatívna produkcia“ a overené zásoby sú počiatočné skutočné zásoby **(Initial reserves)**
- Overené a neoverené zásoby – **zostávajúce potenciálne zdroje (Remaining potential)**

ROPA

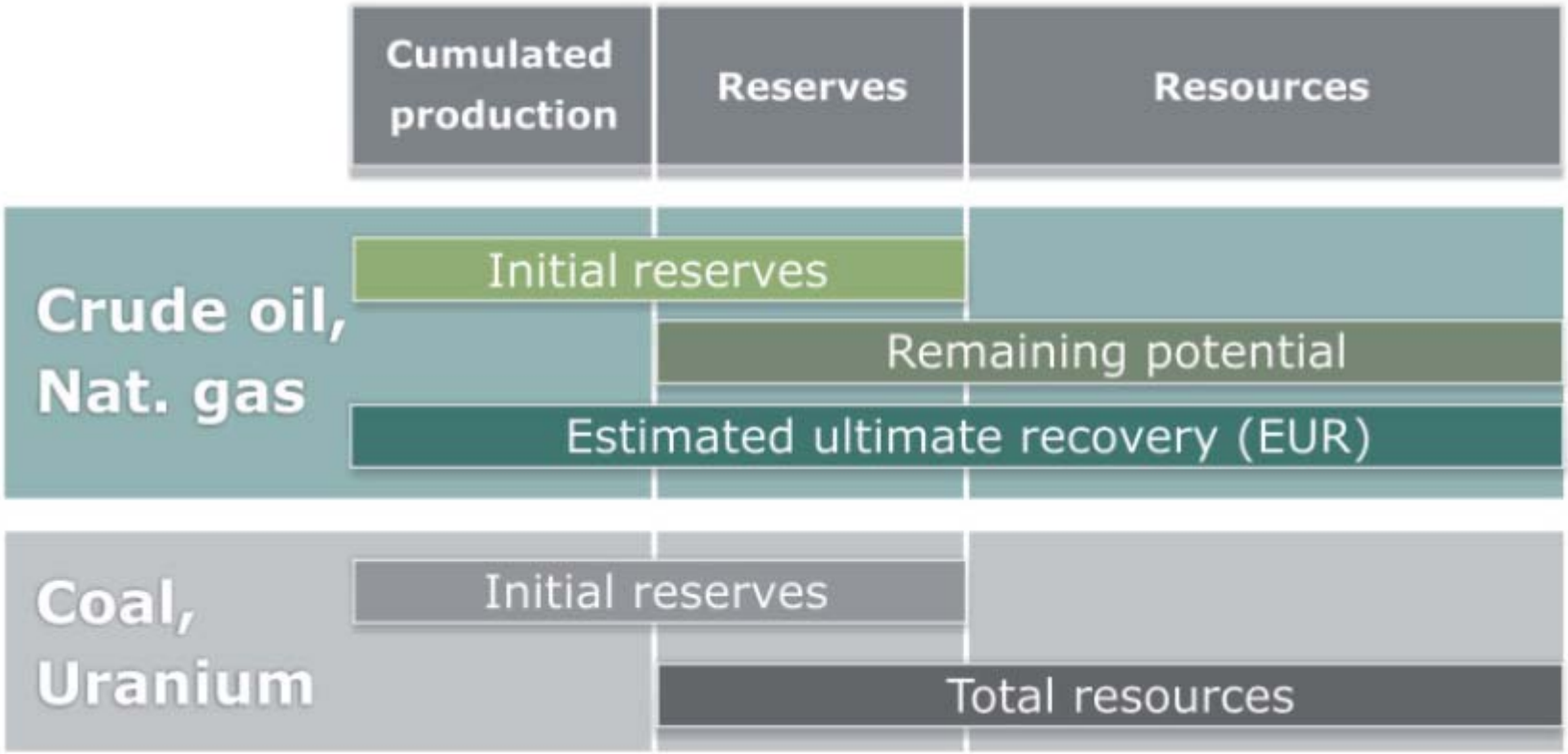
- **Produkcia + overené + neoverené** zásoby sa označujú ako celkové odhadnuté zásoby (zdroje) (**Estimated Ultimate Recovery – EUR)**

Vyťažiteľnosť overených zásob – bilančných je cca 30–40 %

(E – **ekonomická os** – cena ropy F– uskutočniteľnosť otvorenia/ťažby ložiska dĺžka ťažby, návratnosť investícií a zisk

Trend rasu alebo poklesu zásob :

Podľa množstva/veľkosti nových – objavených ložísk ropy (HC) v určitom období, často za posledných 5–10 rokov


Cumulated production
Reserves
Resources
Crude oil, Nat. gas
Initial reserves
Remaining potential
Estimated ultimate recovery (EUR)
Coal, Uranium
Initial reserves
Total resources

Ťažba

primárna – nad 65 %, sekundárna do cca 30%, terciérna – 3–4 %

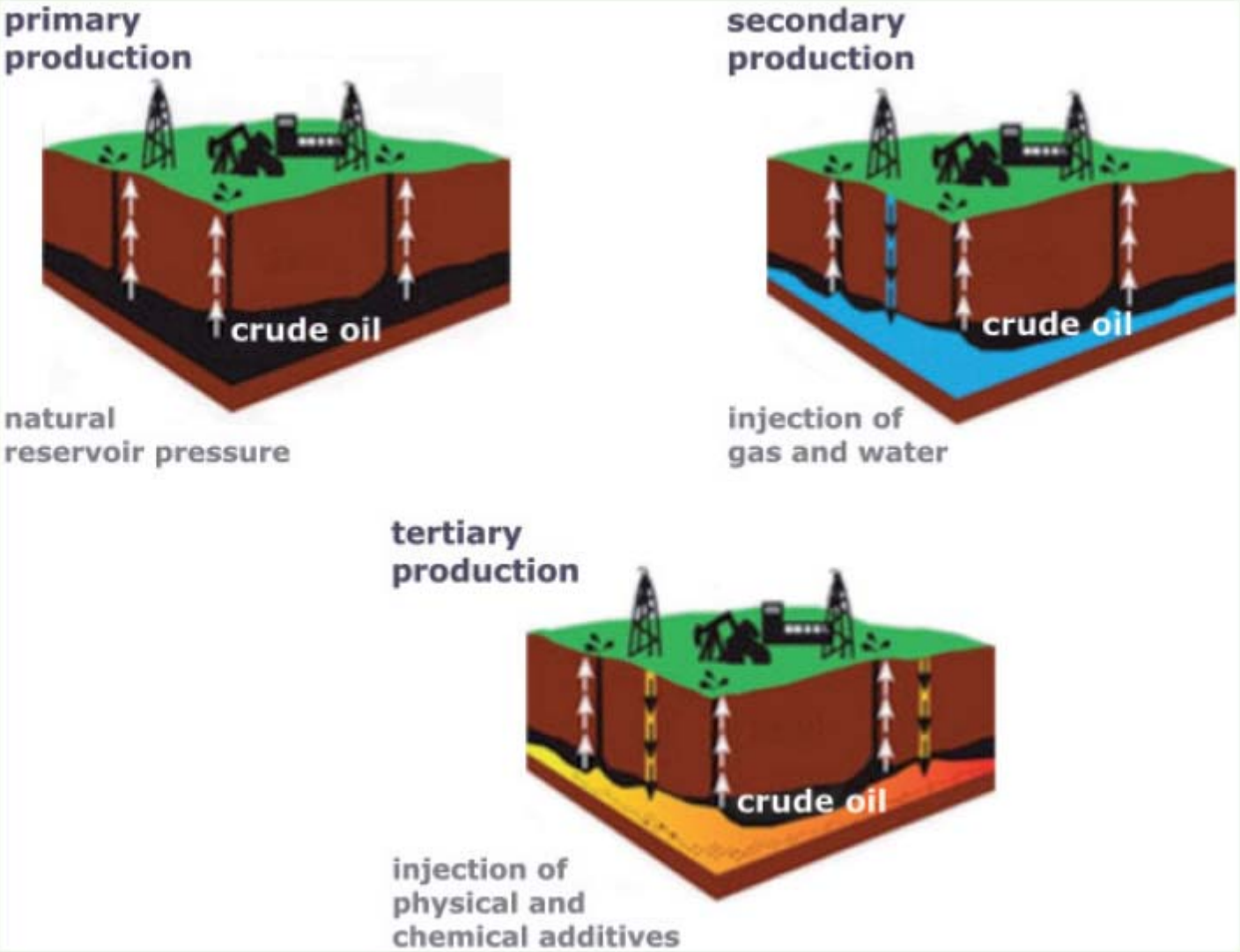


Table 2.1: Classification of Oil and Natural Gas Deposits According to the UNFC (UN, 2003).

Coding scheme	E Profitability	F Feasibility (Project status)	G Geological degree of exploration
10	Profitability (commercial)	confirmed (committed)	proved (proved)
20	conditionally profitable (contingent commercial)	possible (contingent project)	explorated and described (explored and delineated)
30	Not profitable (not commercial)	Exploration	discovered (discovered)
40			expected (prospective)

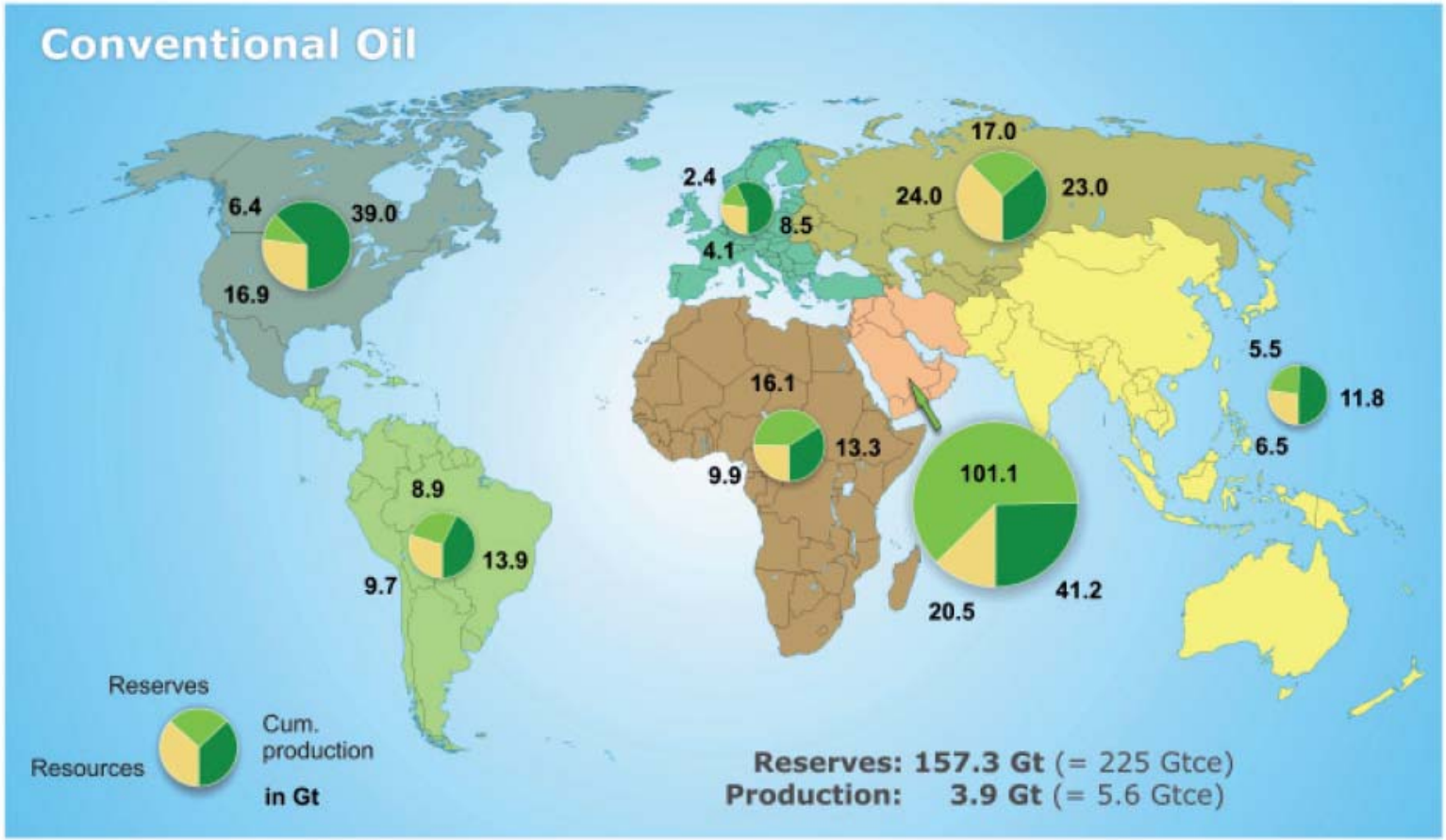
SPE (Society of Petroleum Engineers) (2005): SPE Oil and Gas Reserves Committee Mapping Subcommittee Final Report – December 2005 APPENDIX A Detailed Description of Agencies' Classification/Definitions, 87 p.

— (2007): Petroleum resource management System 2007.- http://www.spe.org/spe-site/spe/spe/industry/reserves/Petroleum_Resources_Management_System_2007.pdf , 49 p.

UN (2003): United Nations Framework Classification (UNFC) applied to Petroleum Resources.- Distr. General: ENERGY/GE.3/2003/1, 17 March 2003, 25 p.

UN-ECE (United Nations Economic Commission for Europe) (2004): United Nations Framework Classification for Energy and Mineral Resources. – (http://www.unece.org/ie/se/reserves.html)

WEC (World Energy Council) (2004): 2004 Survey of Energy Resources. Elsevier Ltd. (CD-ROM)



gure 3.2: Regional distribution of the EUR of conventional crude oil in 2007 (total 400 Gt).

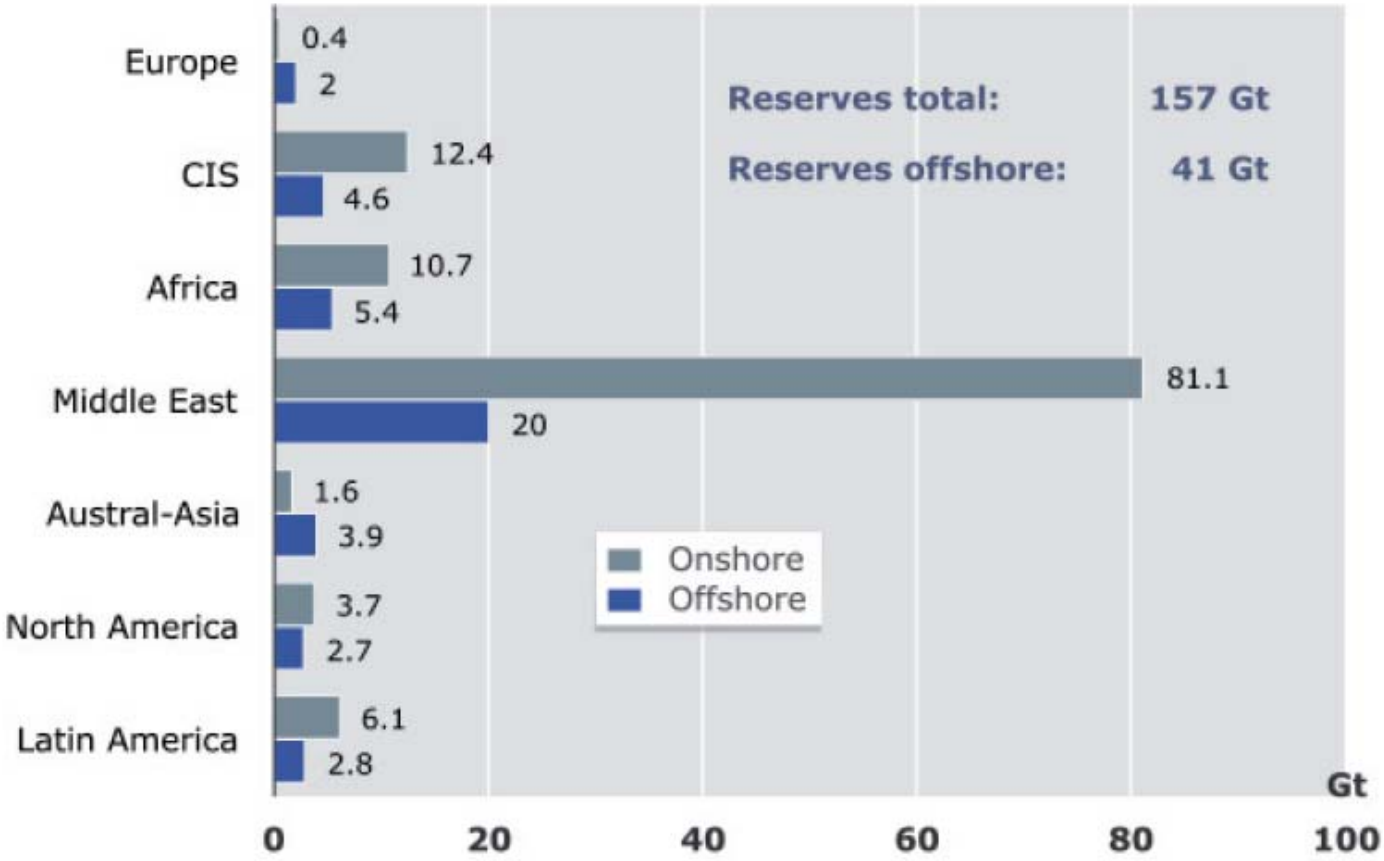


Figure 3.7: Distribution of the reserves of conventional oil in 2007, onshore and offshore, by region.

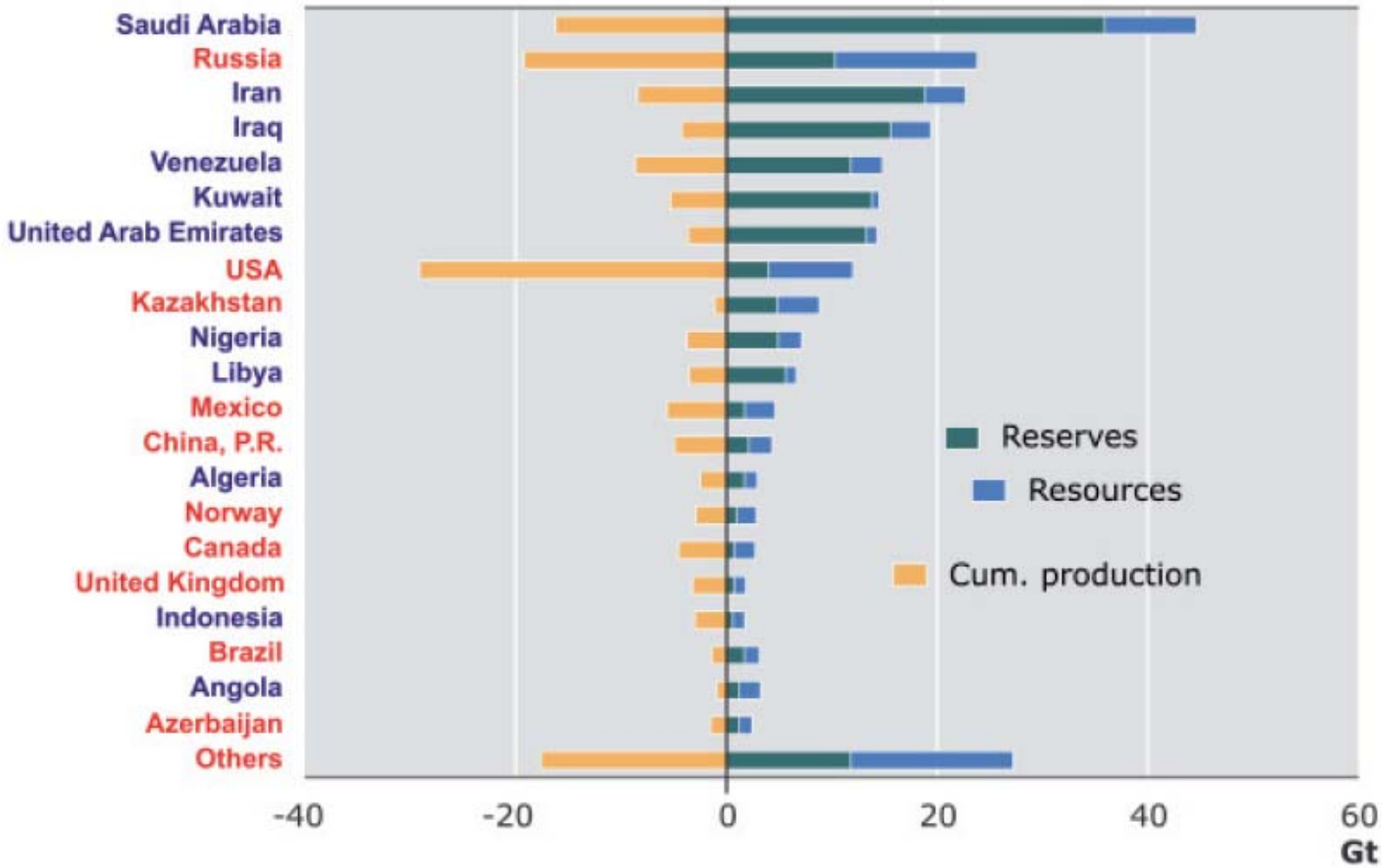


Figure 3.3: EUR of conventional crude oil in 2007: The top twenty countries sorted according to remaining potential (OPEC countries in blue bold-face type).

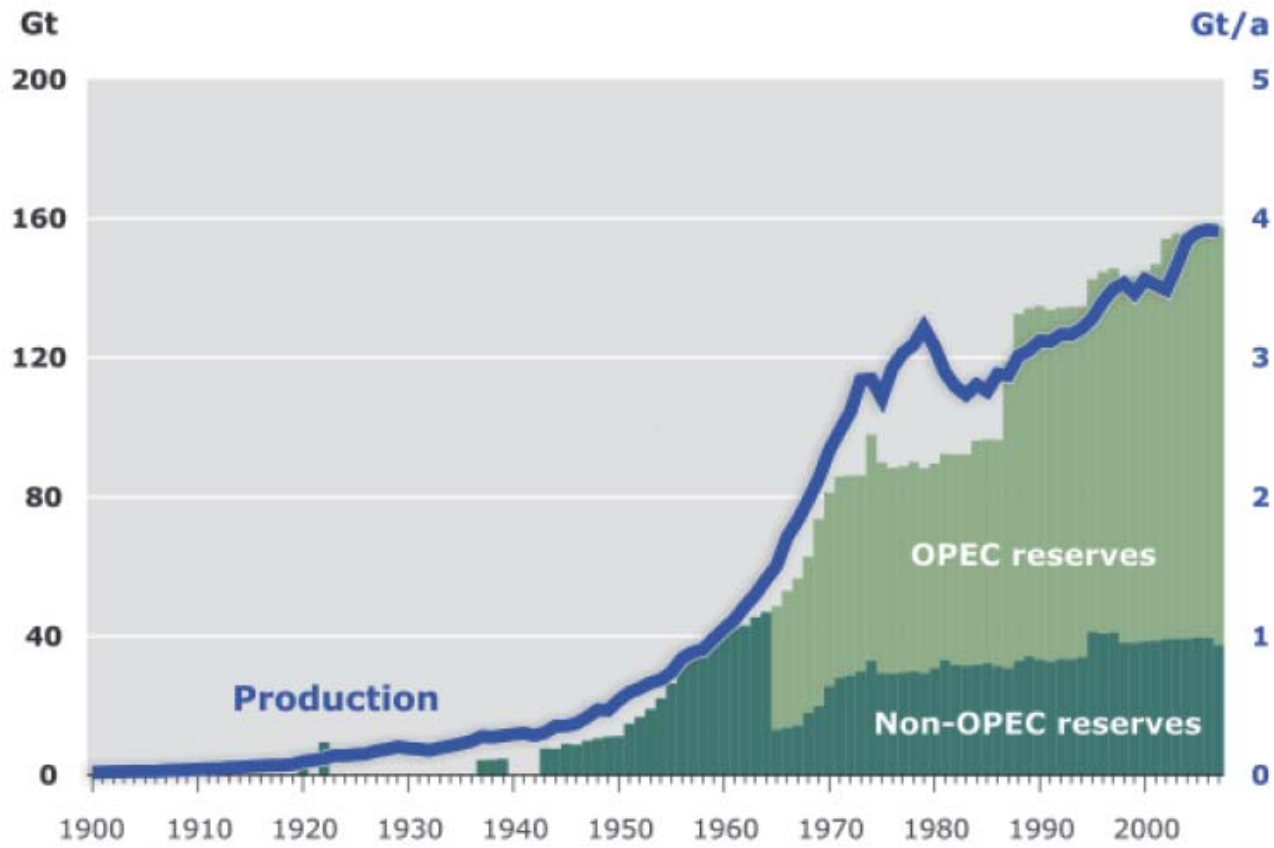
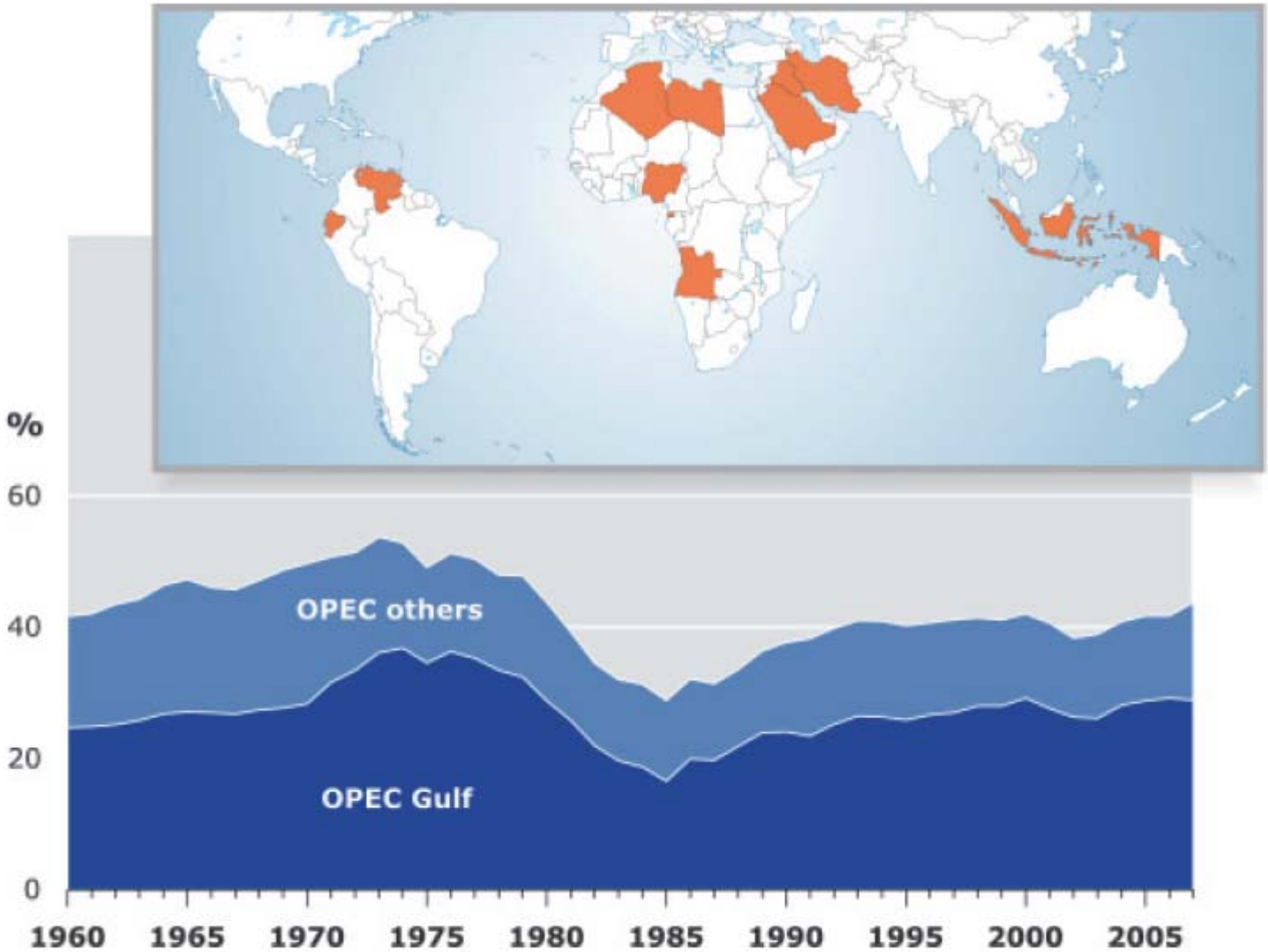


Figure 3.4: Development of the reserves and production of conventional oil from 1900 to 2007.



): Share of the OPEC countries (orange) in the global petroleum production from 1960 to 2007.

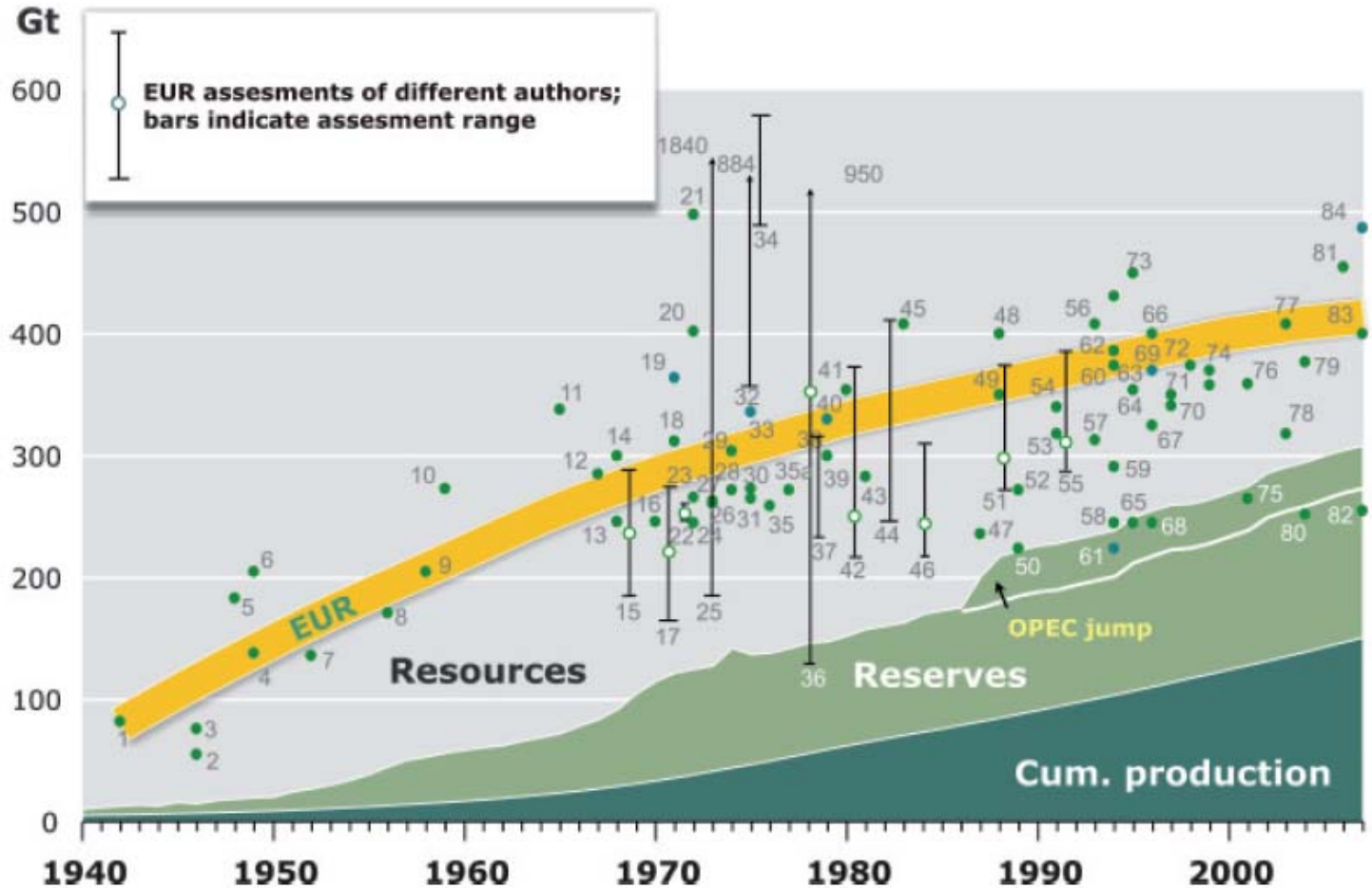


Figure 3.1: Development of the estimates concerning the Estimated Ultimate Recovery (EUR) of conventional oil, the cumulative production and reserves from 1940 to 2007 (sources for numbered references cf. Tab. A 3-1).

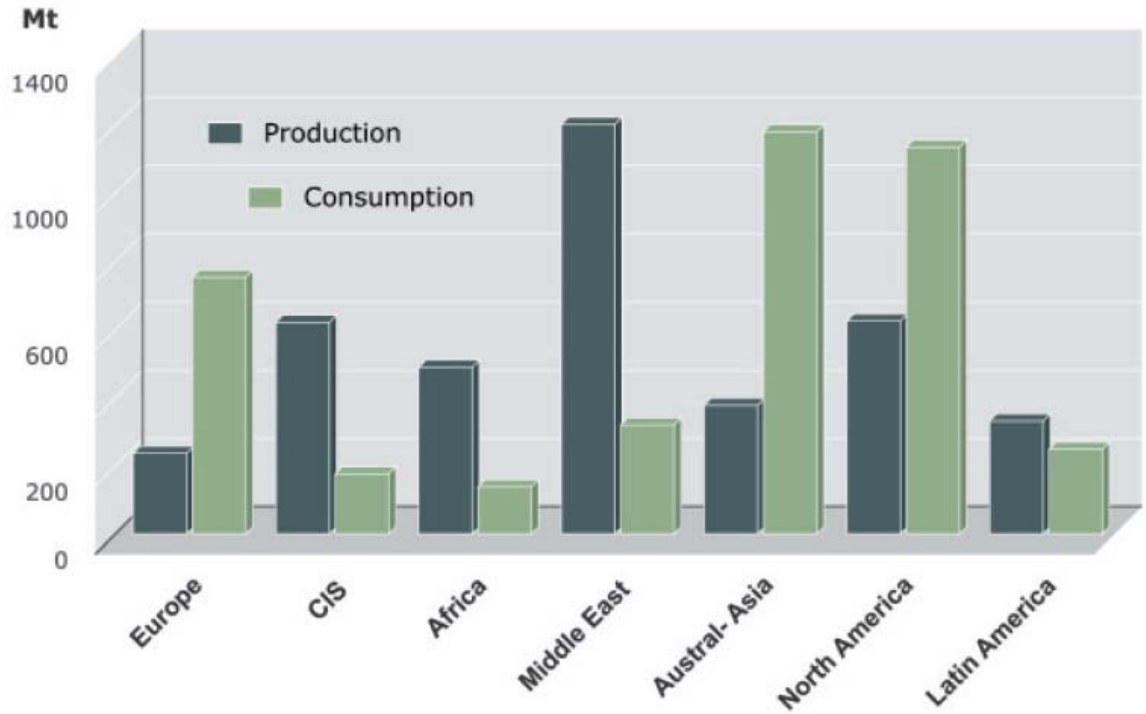


Figure 3.12: Comparison of oil production and consumption in 2007 by region

The oil consumption (petroleum products) rose in 2007 by app. 460 Mt in comparison to 2001 and reached a historic high at app. 3.9 Gt. The consumption is distributed very unevenly when groups of countries and regions are regarded. While the OECD countries consume a little more than 56 % of the mineral oil at 2.2 Gt, the OPEC states consume only little more than 9 %. The regions showing the highest consumption are Austral-Asia, North America and Europe (Tab. A 3-15, A 3-16). Since 1978, Austral-Asia and North America showed the greatest increases, whereas consumption in Europe stagnated and even slightly decreased in the course of the previous years. When production and consumption of individual regions are compared (Fig. 3.12), a definite dominance of consumption over production results for

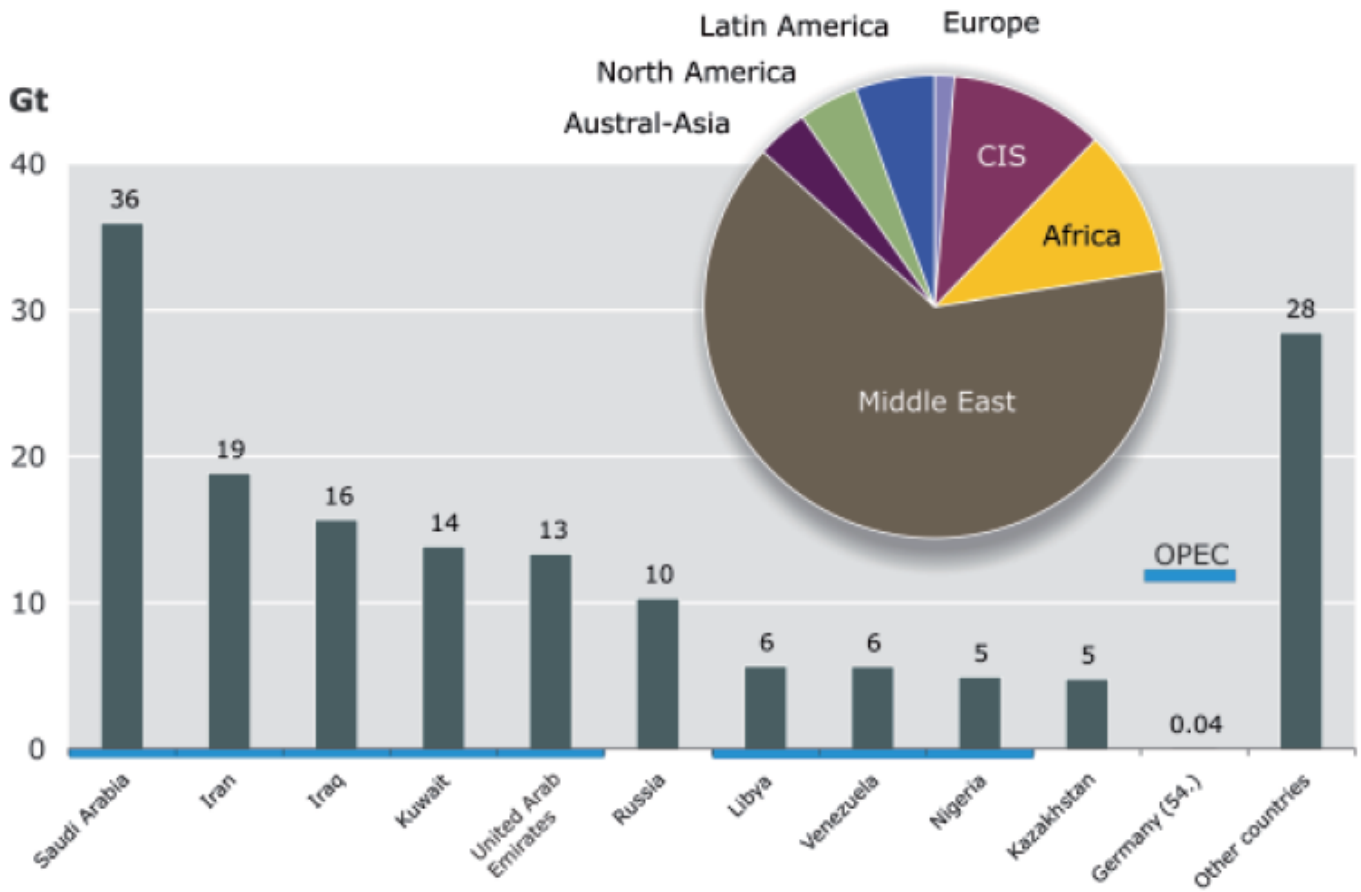


Figure 3.5: Reserves of conventional oil (Total 157.3 Gt) in 2007 of the top ten countries and Germany as well as their distribution by region.

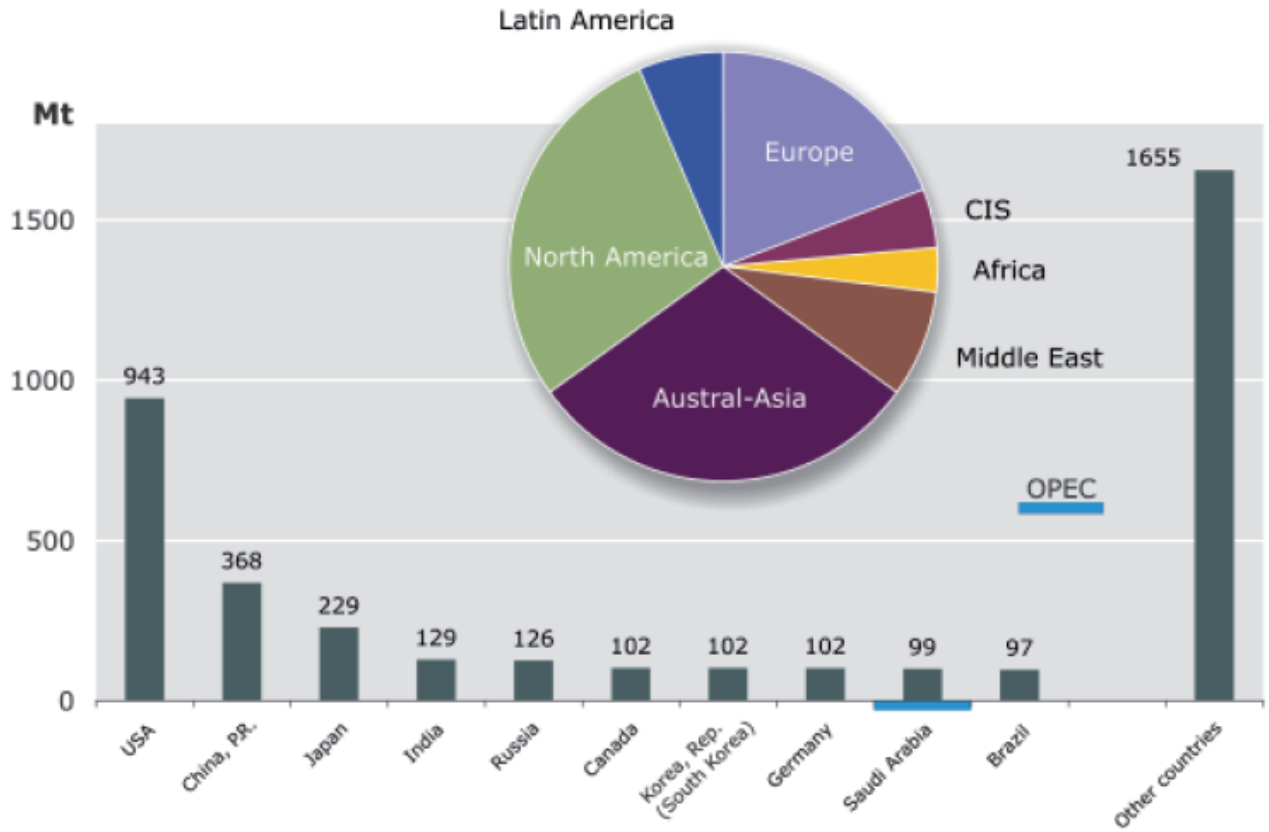
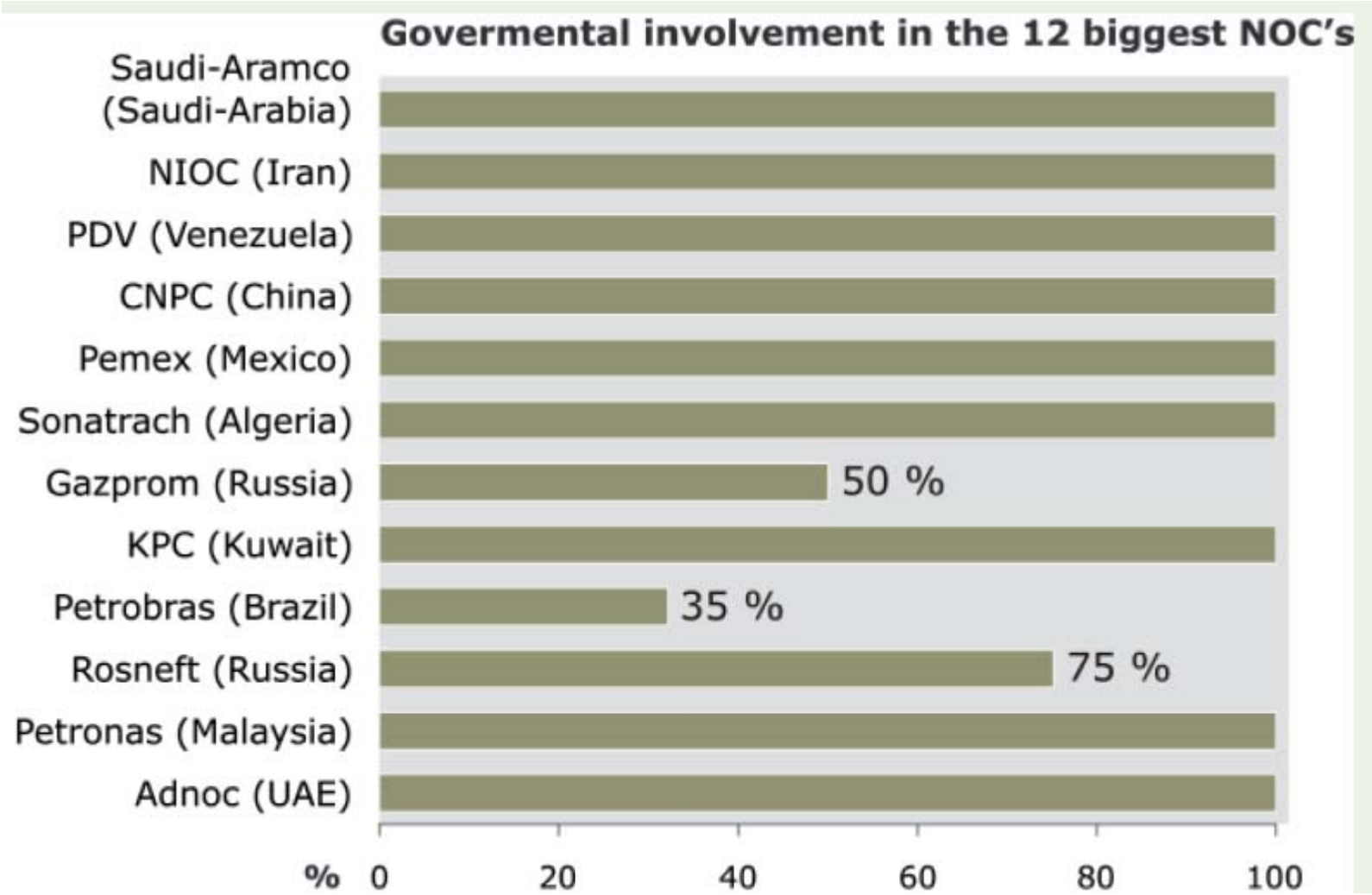


Figure 3.13: Consumption of oil in 2007 (total 3.8 Gt) of the top ten countries as well as distribution by region.


Govermental involvement in the 12 biggest NOC's
Saudi-Aramco (Saudi-Arabia)
NIOC (Iran)
PDV (Venezuela)
CNPC (China)
Pemex (Mexico)
Sonatrach (Algeria)
Gazprom (Russia)
50 %
KPC (Kuwait)
Petrobras (Brazil)
35 %
Rosneft (Russia)
75 %
Petronas (Malaysia)
Adnoc (UAE)
%
0
20
40
60
80
100

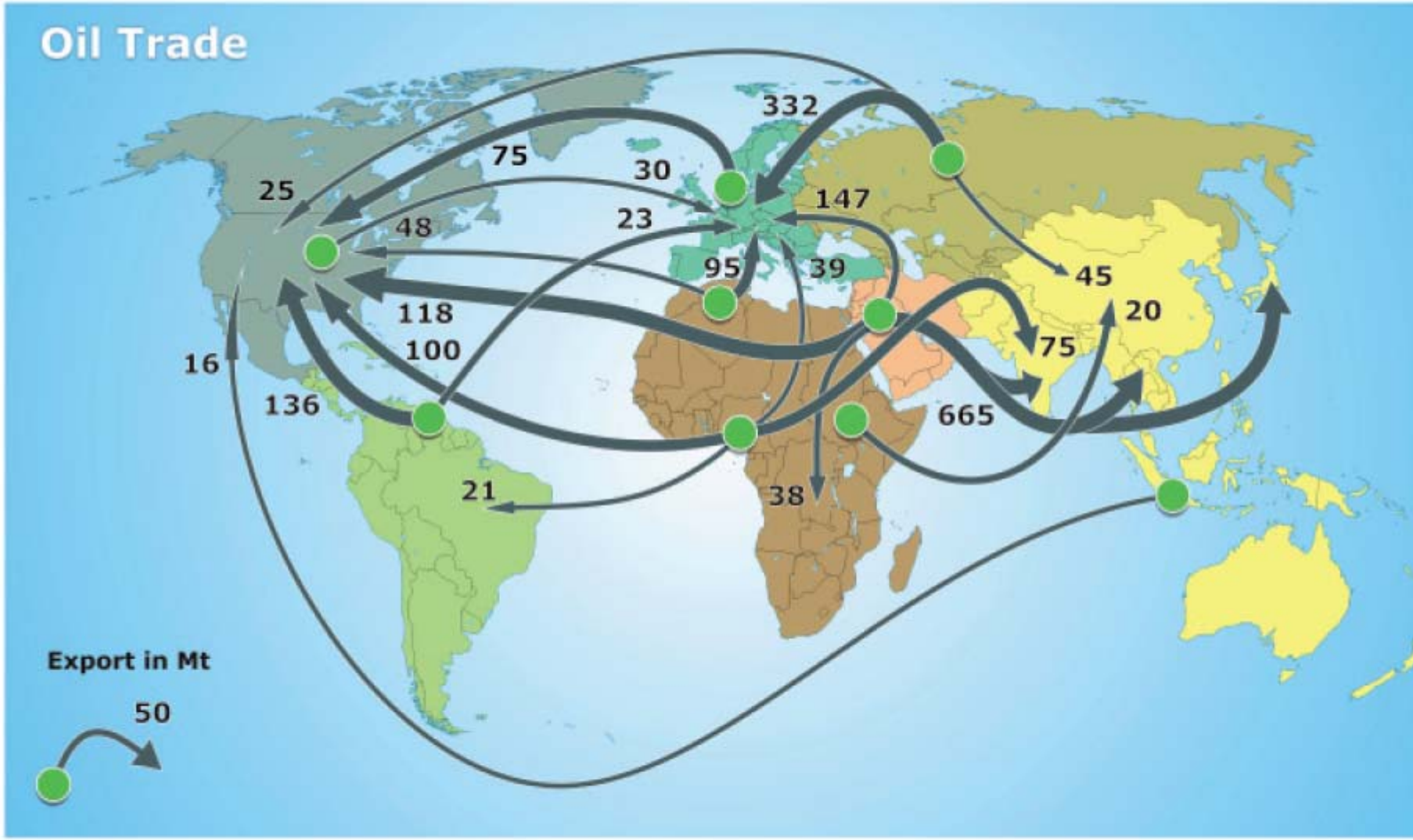


Figure 3.14: Global oil trade movements (crude oil and petroleum products) in 2007 i
(according to BP, 2008) without consideration of intraregional trade

CENA ROPY

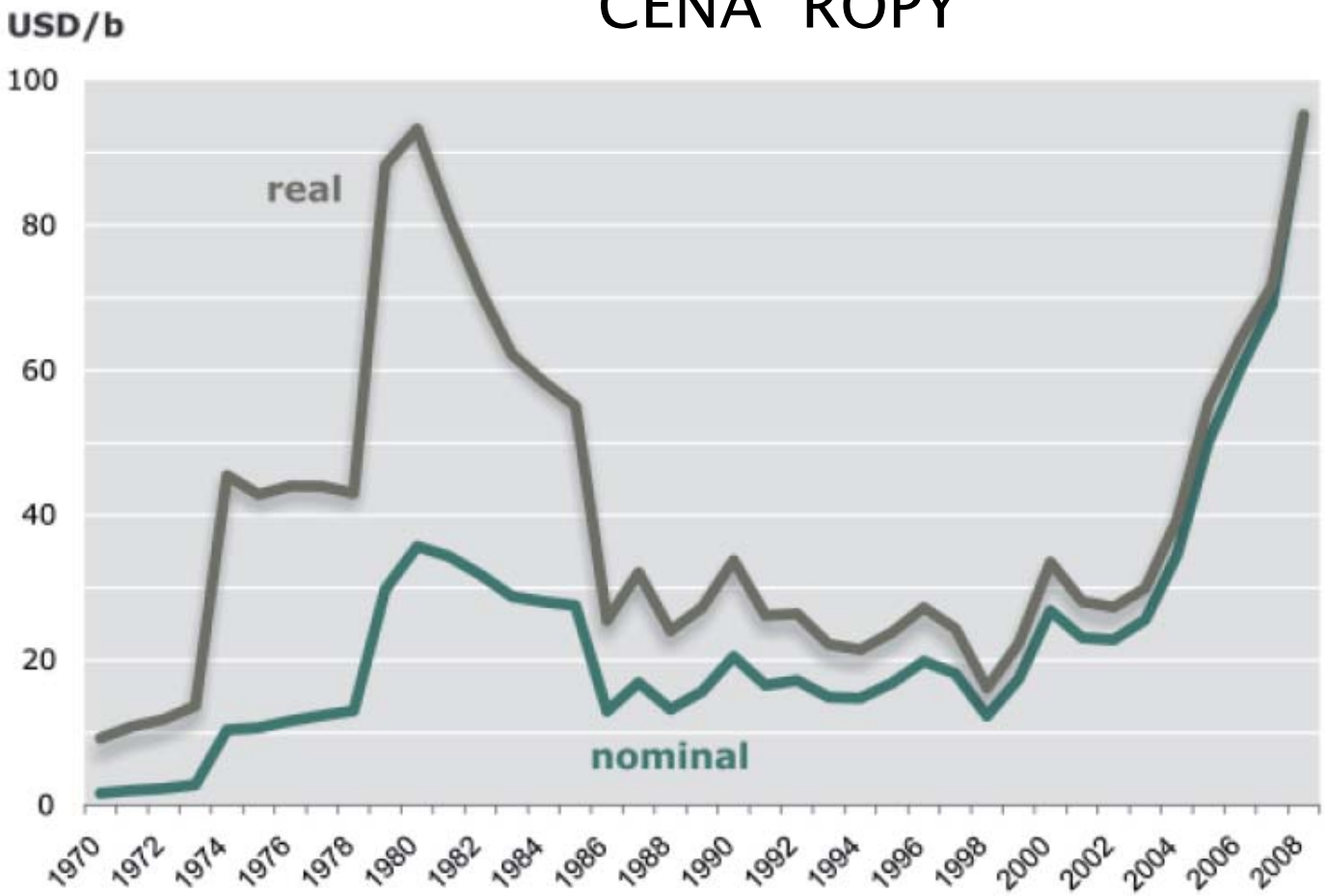


Figure 3.16: Development of the prices for crude oil between 1970 and 2008 real ($_{2008}$USD) and nominally (current rate of the currency) for the oil type Arabian Light in mean annual values.

Cena 2000–2009

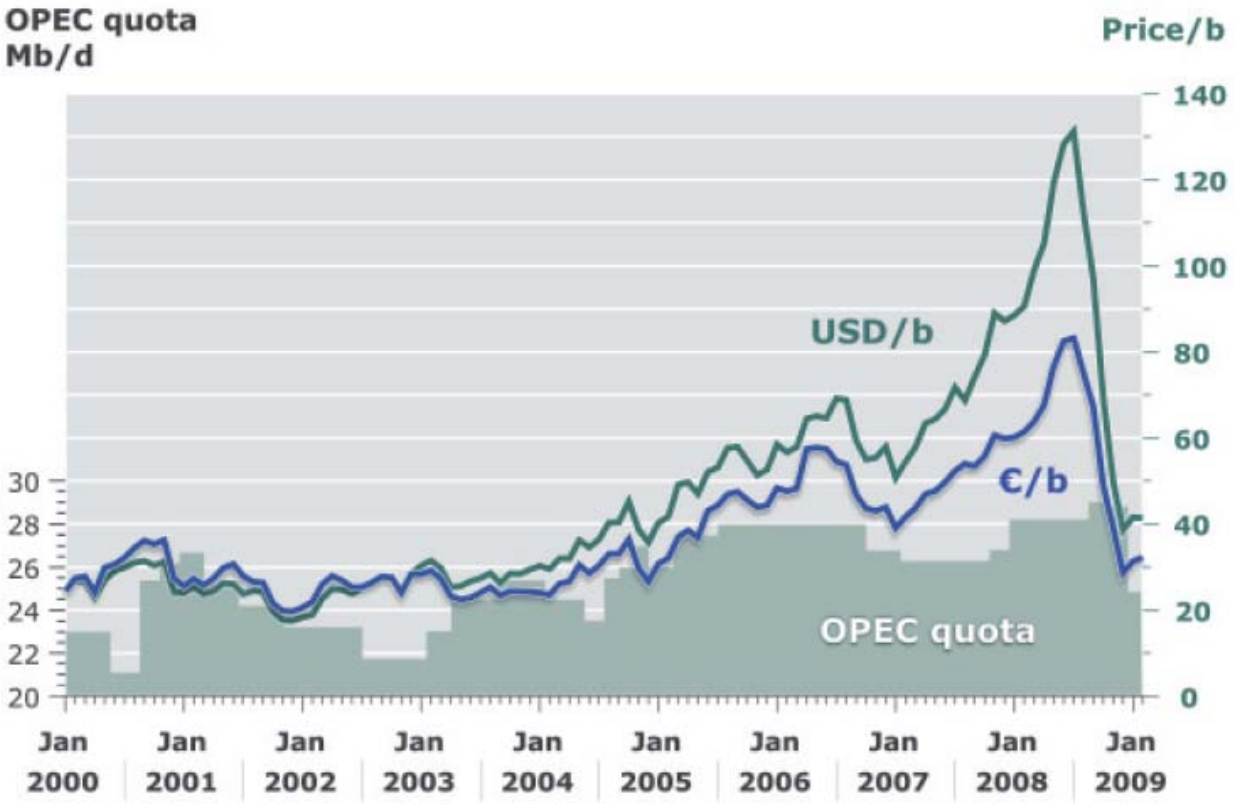


Figure 3.17: Development of the oil prices for OPEC basket in USD and Euro per barrel (monthly mean) as well as the OPEC-10/OPEC-11 (from 9/2008) production quota.

Spotreba– vyčerpanie zdrojov

M. King Hubbert (1903–1989) was an American geophysicist best known for his accurate prediction of the peak in oil production in the lower 48 United States. In a 1956 paper, he published what is now known as the **Hubbert Curve**, a simple mathematical model of oil supply; he used this to predict that the peak of crude-oil production in the United States would occur between 1966 and 1971. It actually occurred in

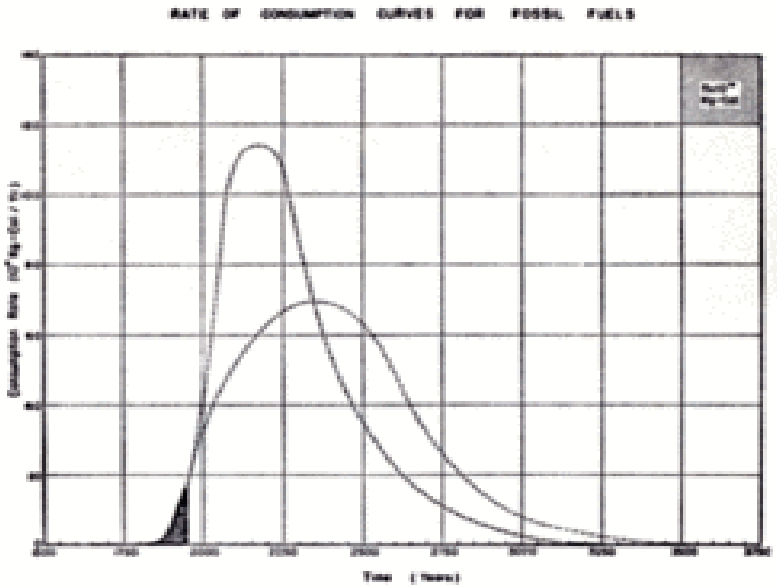
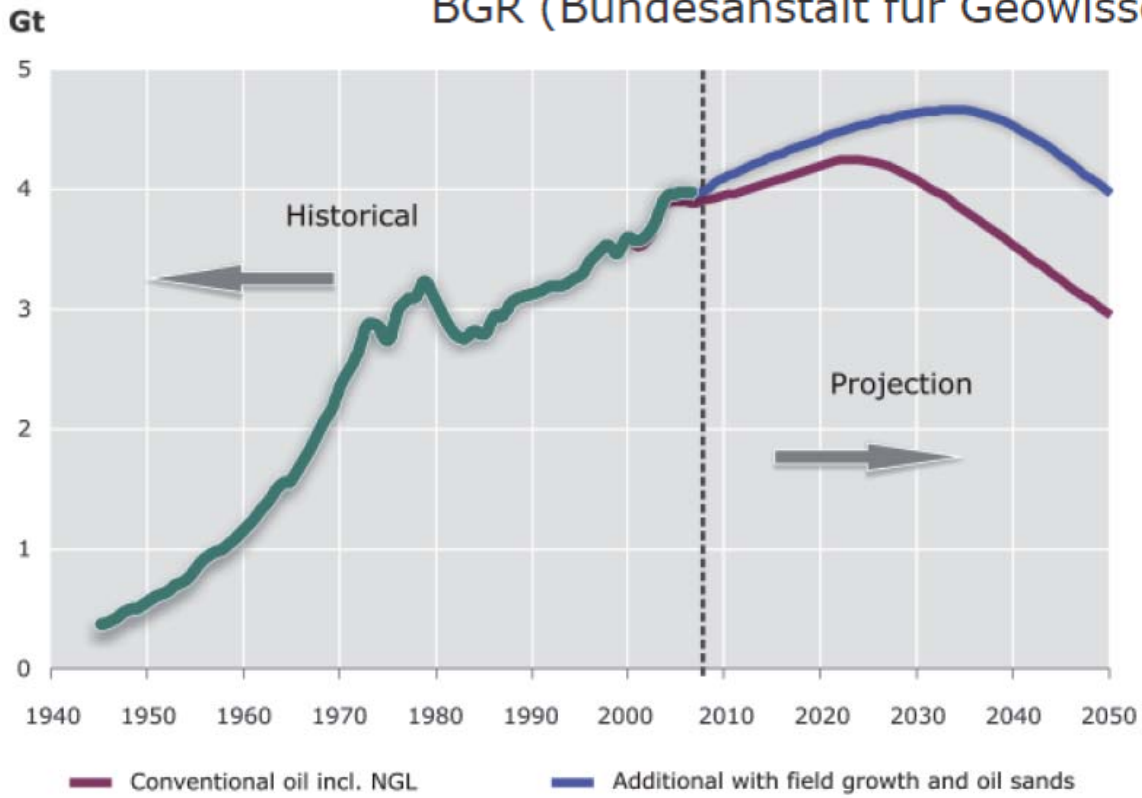


Figure 6. Rate of consumption curves for fossil fuels. (Source: "Science", February 4, 1949)

Assuming that the land areas of the United States will produce 16 x 10^9 cubic meters (100 billion barrels), then a reasonable estimate for the world would be:

Land:	160 x 10^9 cubic meters
Continental Shelves:	160 x 10^9 cubic meters
Total:	320 x 10^9 cubic meters

BGR (Bundesanstalt für Geowissenschaften und Rohstoffe)



:: Historic development of oil production and projected course of production for conventional oil including condensate (NGL) and additionally taking into account the oil sand production and increases in reserves (Field Growth).

Based on the existing general requirements of the oil market for an optimum use of the reserves and resources, the global maximum of the production of conventional crude oil will be reached around 2020. If, in addition, increases in reserves from producing deposits and the possible production of oil from oil sands are taken into account, based on the mentioned prerequisites, an increase of the production until 2035 is possible (Fig. 1.2). According to the projections conducted in the course of this study, the future production of oil will not exceed 4.7 Gt per year. Just as for natural gas, the remaining reserves are increasingly concentrated in the strategic ellipse. National state-owned oil companies are increasingly forcing international trusts into the background, where access to the reserves and production are concerned.

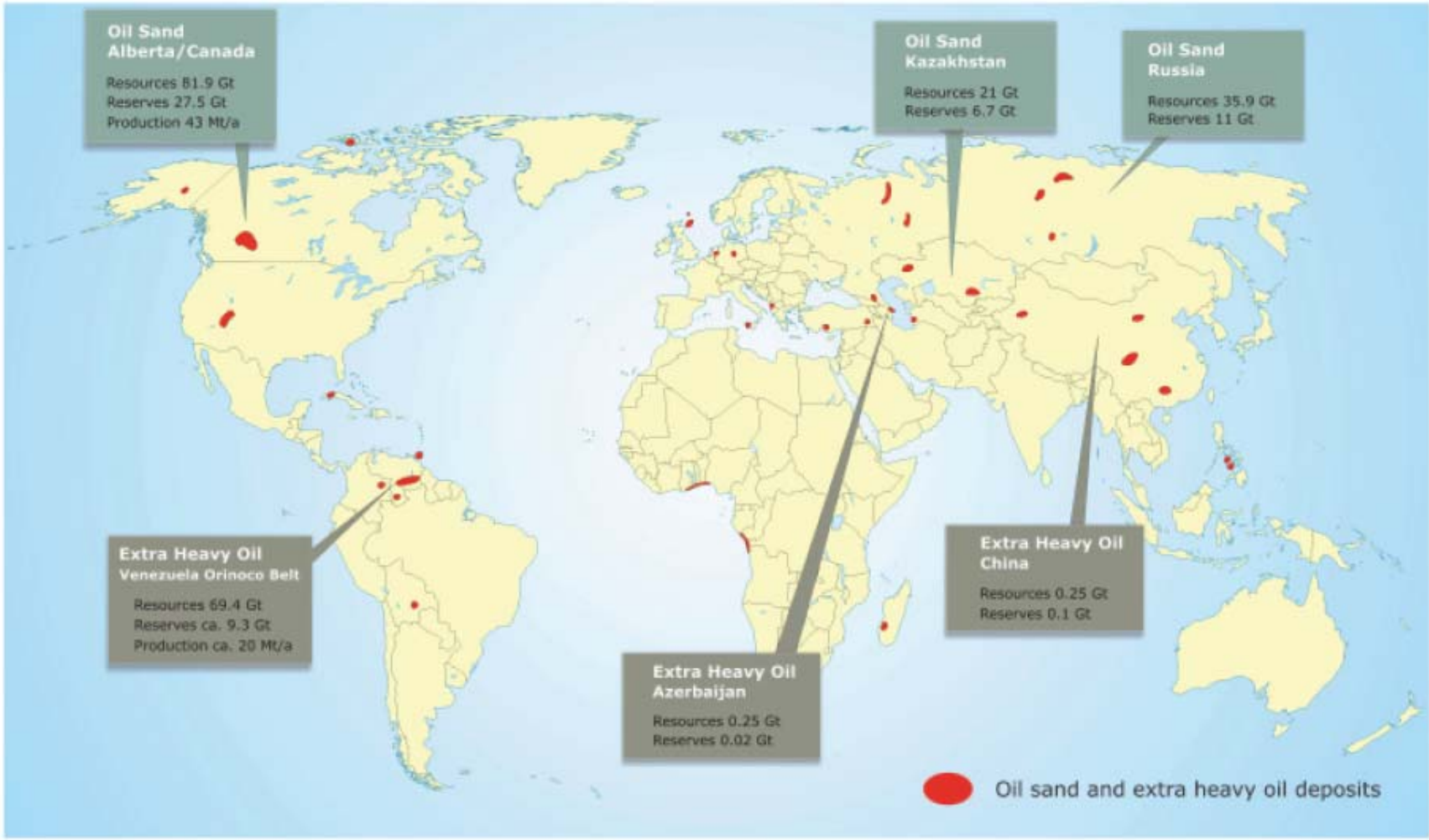
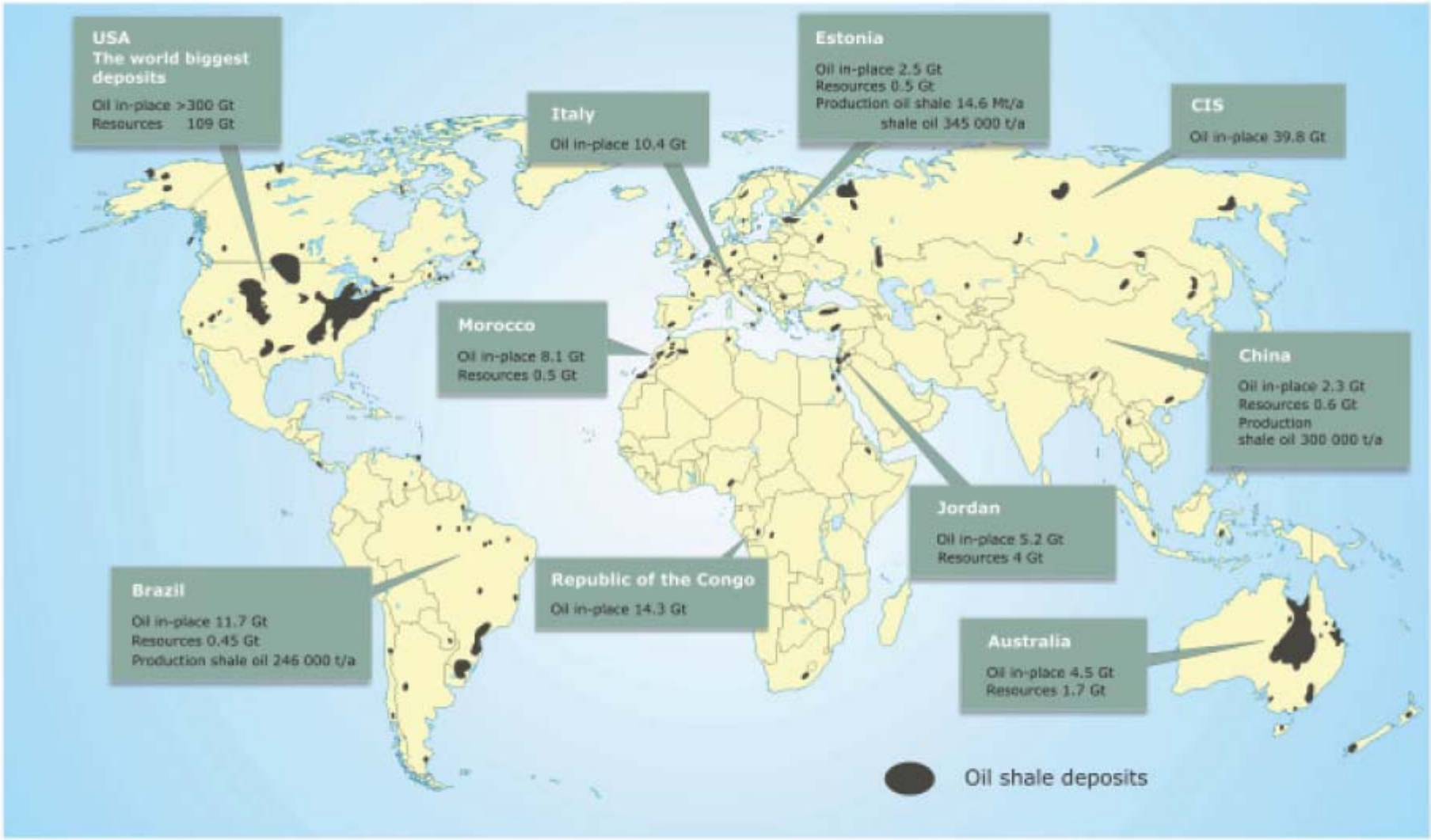
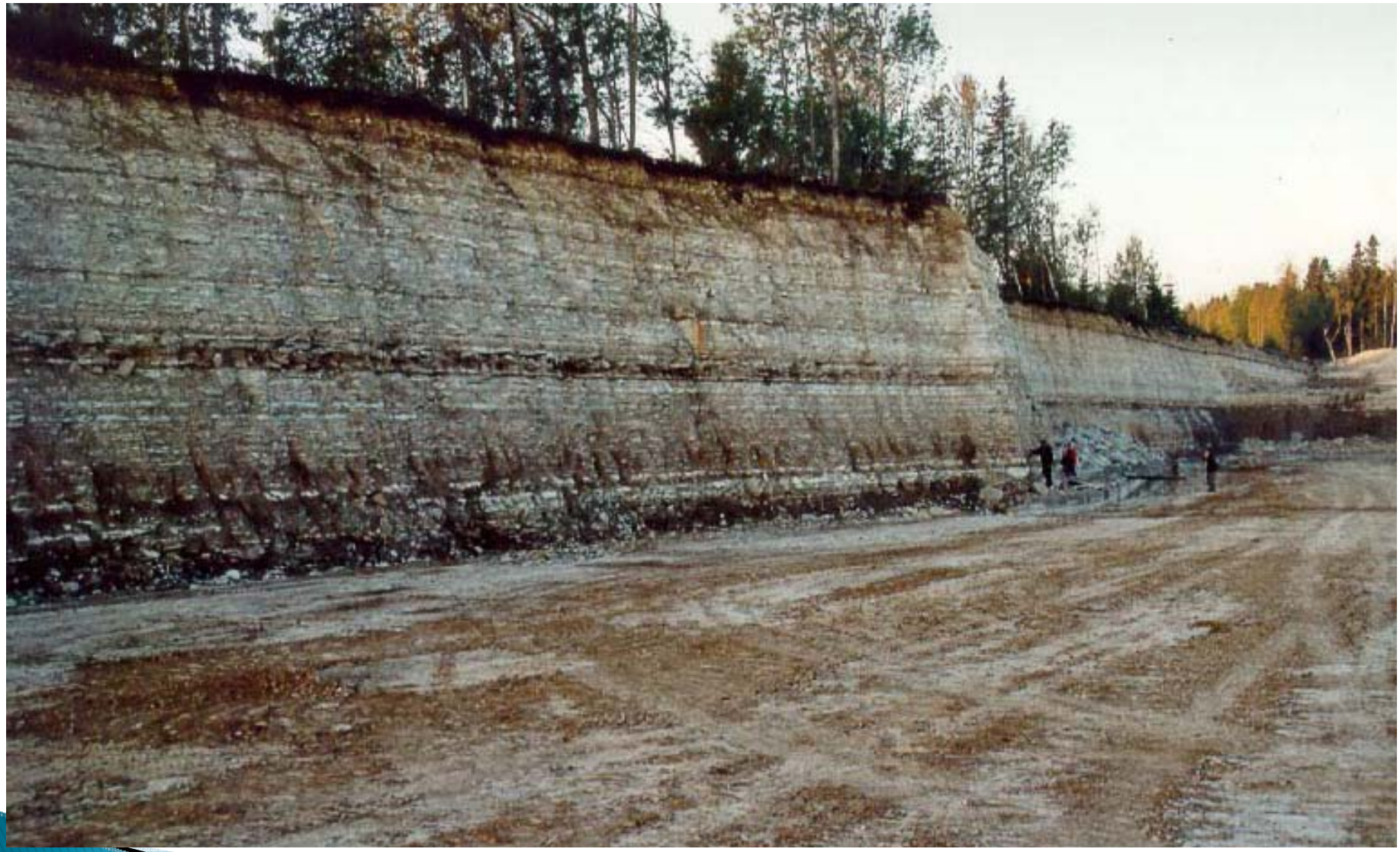


Figure 3.19: Distribution of the known worldwide occurrences of oil sand and extra heavy oils with information on reserves, resources and production.



ure 3.22: Regional distribution of the oil shale occurrences worlwide with data concerning reserves, resources and production.