Tomorrow's Explorers*

Arthur R. Green[1]

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[1]ExxonMobil (retired), Gig Harbor, WA (argreen4004@comcast.net)

Types of Petroleum Explorationists

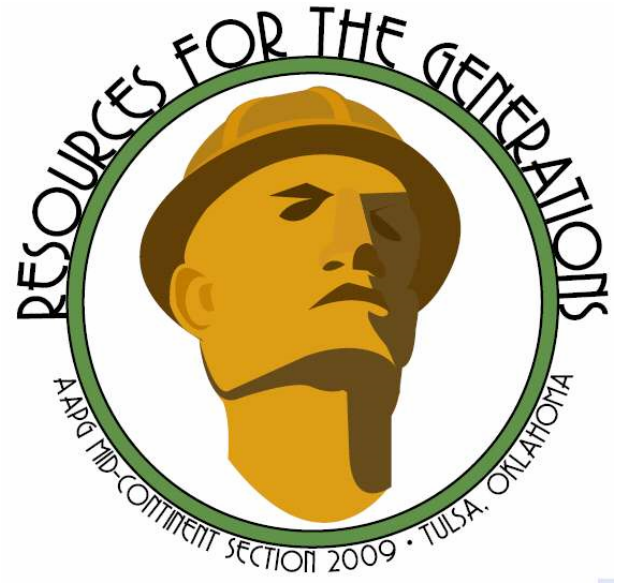
- Global explorationist
- Generic area explorationist
- Trend explorationist
- Step-out explorationist

Professional Characteristics

- Solid broad geosciences background
- In-depth expert in one field of the geosciences
- Uses systems thinking
- Creates mental models
- Builds a shared vision
- Uses modern tools
- Fluency with the global internet
- Constant learning and intense curiosity

The Hard Truth: Workforce

"A majority of the U.S. energy sector workforce, including skilled scientists and engineers, is eligible to retire within the next decade. The workforce must be replenished and trained." (NPC Global Oil and Gas Study)



Tomorrow's Explorers

Art Green, ExxonMobil (retired)

AAPG Mid-Continent Section Meeting

October 13, 2009

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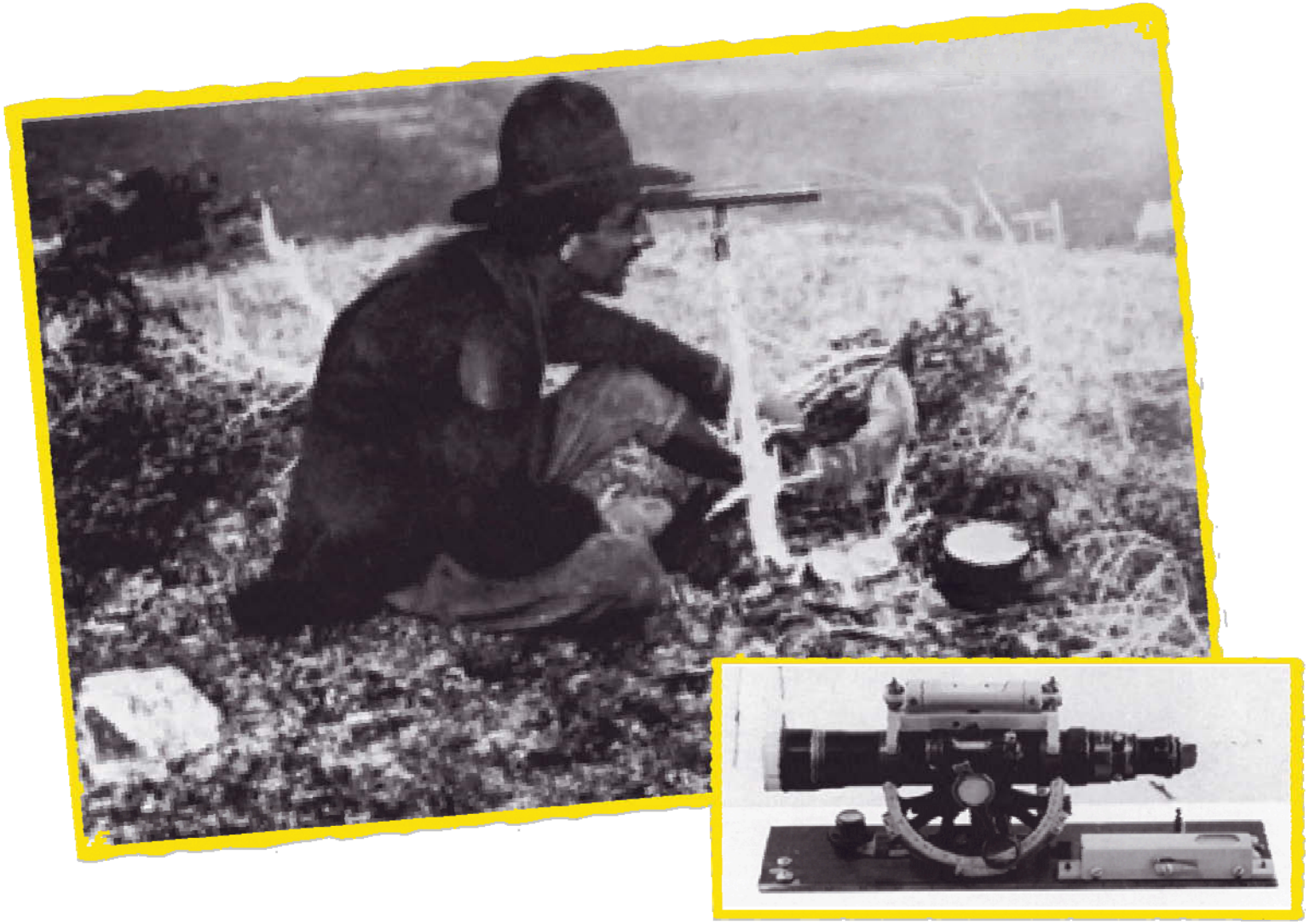
Theodore Link/ Application of Fundamental Technology



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Types of Petroleum Explorationists

- **Global Explorationist** – has a grasp of the Earth as a dynamic, living planet that creates sedimentary basins, fills them and heats and matures them to create petroleum and mineral deposits. To find oil the explorationist must first pick the "right" basin with petroleum system analysis, looks for giant fields with high flow rates and high quality light crude oil or sweet gas.
- **Generic Area Explorationist** – Has an understanding of the DNA of a group of sedimentary basins with a similar temporal, tectonic, and sedimentological history; creates mental models that depict the hidden location of oil and gas deposits in an area with known production. Many old basins that were considered dead have been revived three or four times by someone with a new play concept.
- **Trend Explorationist** – Has explicit an tacit knowledge of how the play parameters of source rock – maturation- migration and entrapment work in a given producing trend. May involve structural, stratigraphic or hydrodynamic traps.
- **Step-Out Explorationist** – Has a grasp of the data and information and knowledge of complex and subtle traps that may contain hidden resources; understands what technological tools will best enable the pinpointing of small accumulations in a specific area of production.

- Petroleum explorationists practice their profession in a wide range of situations:
  - Individual
  - Consultant
  - Small independent company
  - Large company or corporation
  - National oil company
  - Etc…..

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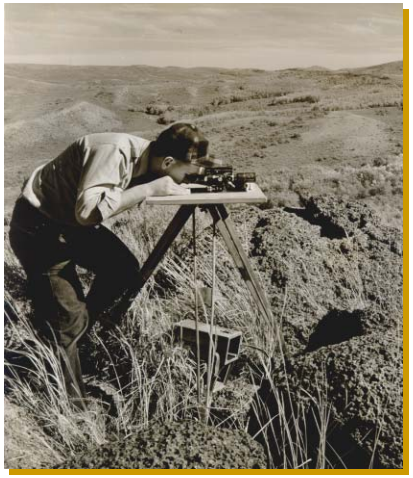
The Years of Discovery



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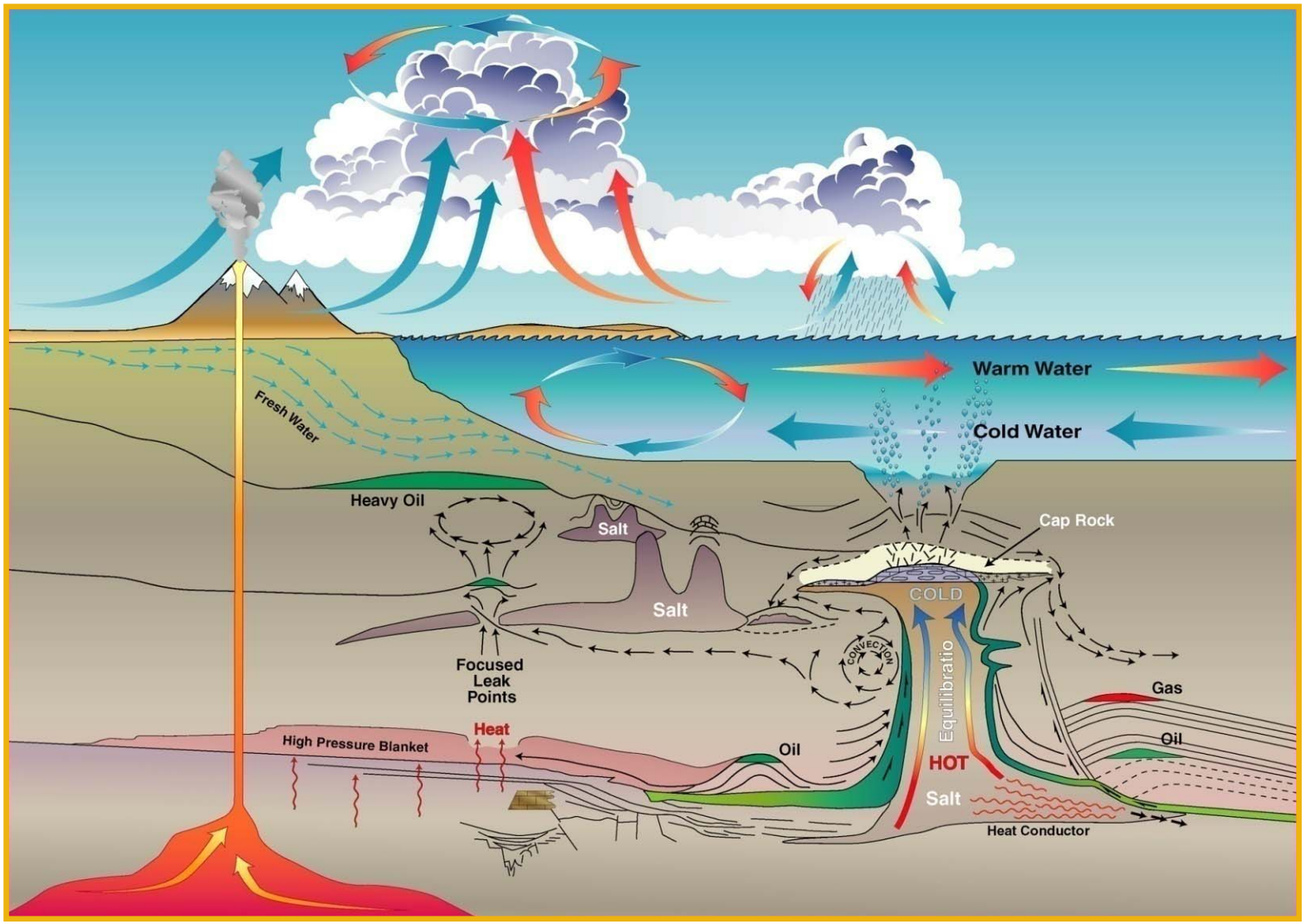
Systems Within Systems….



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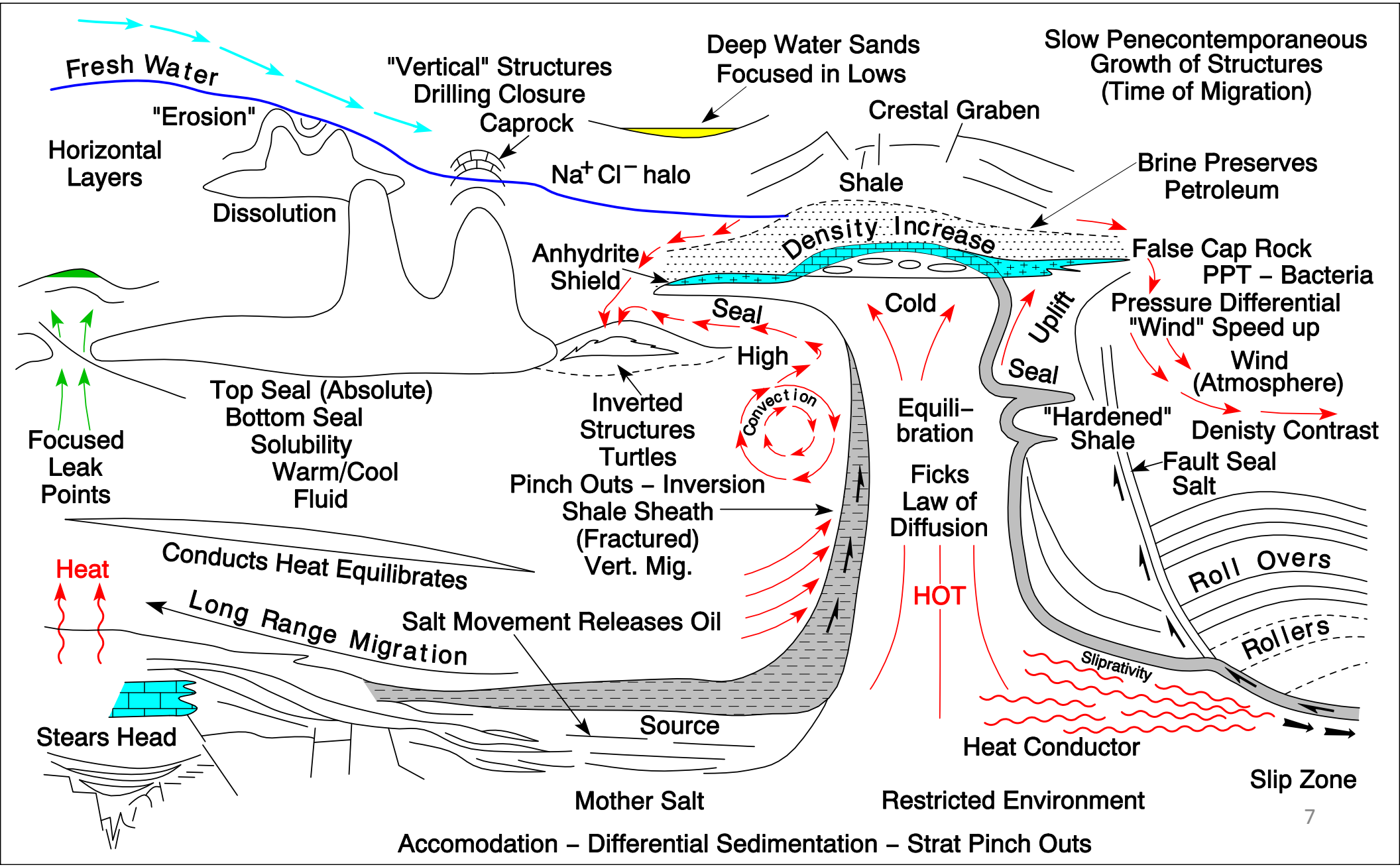
A Forgiving Influence: Salt In The Petroleum System
(Open-Closed-Chaos Systems)
Sources, Primary – 2nd, 3rd, 4th Migration, Trap, Seal (T&B), Maturation, Preservation



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Human Characteristics of Successful Explorationists I Have Known

- Have an understated form of high self-esteem
- Have a passion for finding and producing oil and gas and do it for the game more than the money, prestige, or approval from others
- Their best ideas come from "seeing obvious" things that others miss – connecting the dots, they see non-linear connections between incomplete data points
- "Seeing" events often happen beyond normal work hours because they have no work hours
- When on the trail of an idea or concept, it is focus, focus, focus. Because of this absorption in their vision, they may have relationship challenges – sometimes may appear abrasive or opinionated.
- They are curious. Always asking, "what if?", and seeking truth and admitting if a breakdown occurs in the logic of their mental model and they become obsessed with "fixing it."
- They know themselves well and exhibit a sense of mission and enthusiasm for their work, and life in general.
- Because of their self confidence, they trust their gut instincts, use intuition and tacit knowledge of nature as they see it to be decisive.
- They view dry holes and failure simply as valuable learning experiences or as changes to get data to improve their mental model, and, therefore, they accept risk well.

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Walking in the Subsurface World

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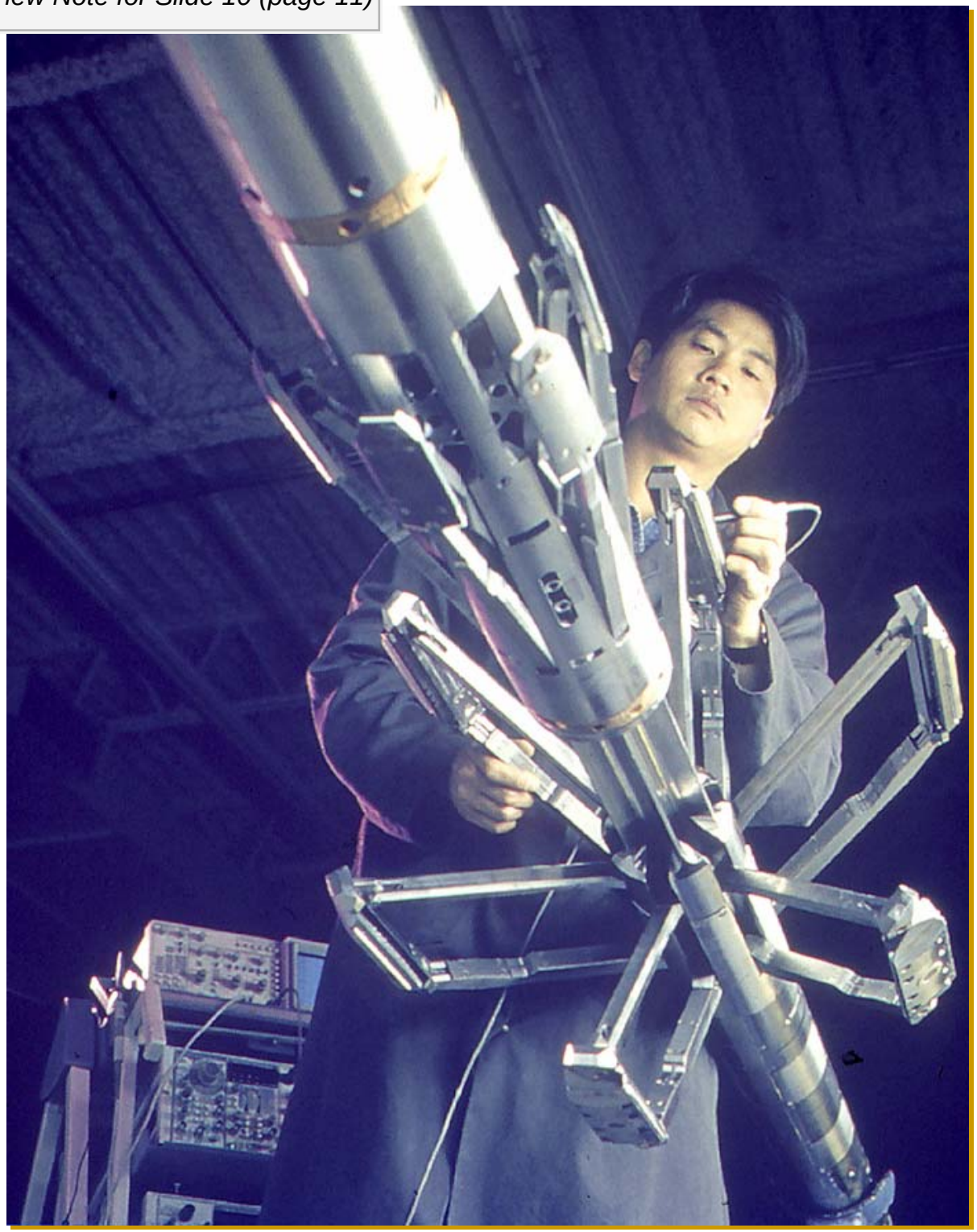

Exploring the Subsurface High-Pressure, High-Temperature “Atmosphere”

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Deep Water Drilling

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The Hard Truth: Workforce

"A majority of the U.S. energy sector workforce, including skilled scientists and engineers, is eligible to retire within the next decade. The workforce must be replenished and trained."

NPC Global Oil and Gas Study

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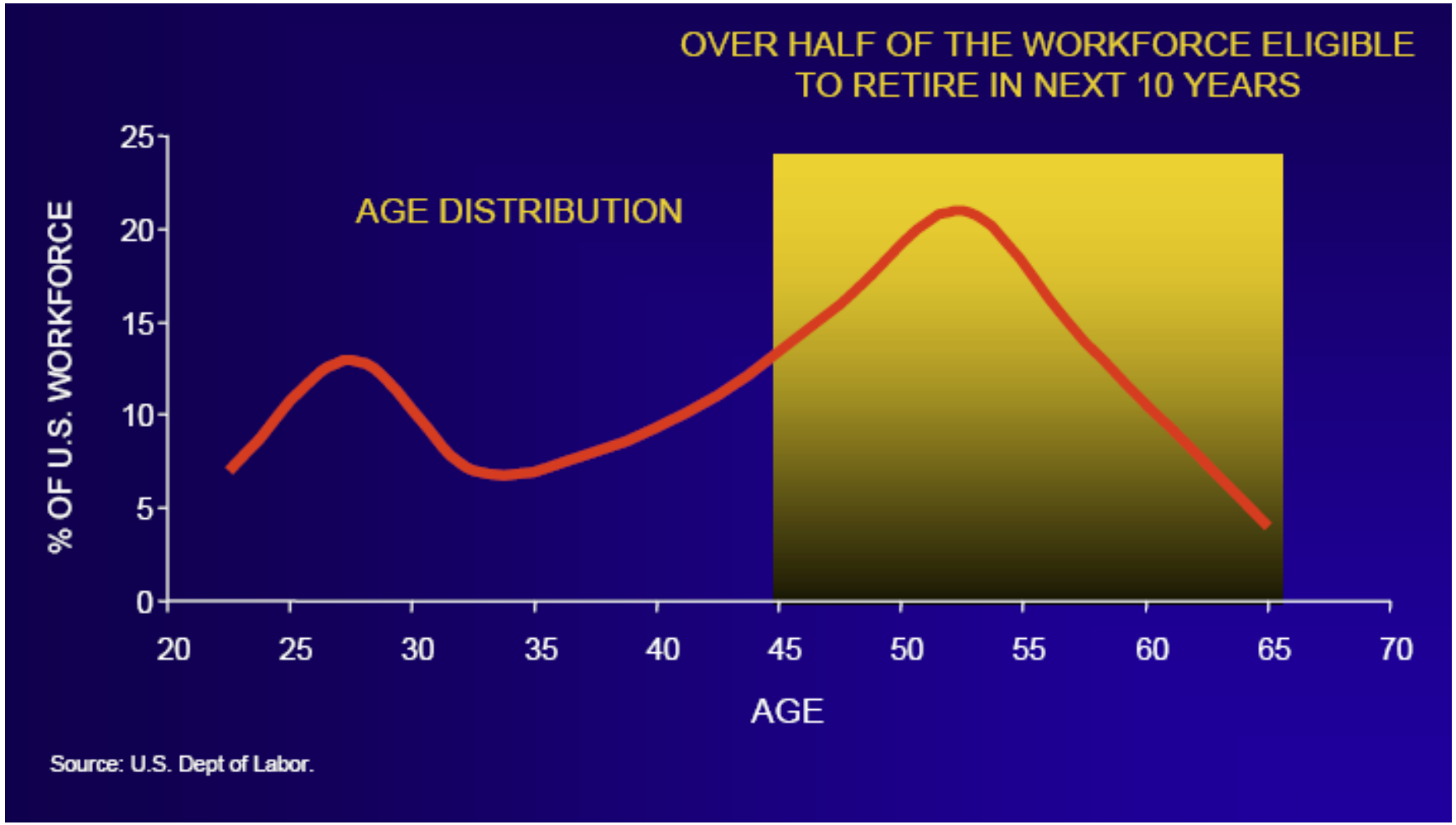
US Human Resources Challenge



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Angola Rig

Notes

Slide 2. There are a number of great energy explorers at this meeting, and I am always proud to be with the people in this business.

When we think about petroleum explorationists, memories of a lot of old friends come back. I shall note some of the ways they looked for oil and gas. Theodore Link was one my first heroes, along with Lewis Weeks and Wallace Pratt with the Humble Company, but there are many names that will never be heard; they were also good at their trade.
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Slide 3. First, I suppose we should ask what is an explorationist? In the future I think we shall need many types of minds to find the oil and gas we need, but they are all really explorationists with many different ways of uncovering the secret places where oil is hidden.
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Slide 4. Looking for oil and gas has changed, but is still the same in many ways. The 60's and 70's were a fun time with an abundance of places to look. It is a little tougher now, but there is still a lot of oil and gas out there hiding.
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Slide 5. There are some common professional characteristics shared by oil finders I have known:

- A solid, broad **geosciences background** (formal or informal). Thinks in a stream of thought from data to information to knowledge to wisdom and is intellectually honest to himself or herself.

- A rigorous, in-depth **expert in one field** of the geosciences (geology and geophysics). Knows and communicates with others in the discipline.

- **Systems thinking** is fundamental to their thought process. Thinks of sedimentary basins as live subsurface "atmospheres". Believes that the complex fluid system can often exhibit collective properties "emergent features" that are lawful in their own right. He has tacit knowledge of these laws in a given basin or area of exploration.

- Creation of **mental models** that are constantly reinforced or refined as new data and information are assimilated. These hydrocarbon systems or fluid models envision the flow of oil and gas from source rocks through conduits to traps.

- The ability to verbalize or visually depict the mental model and can build a **shared vision** with those who can add to the model or support it into an action step. Language skills are becoming more important as globalization develops and partnerships are multinational and multicultural.

- Technical skills with a broad range of the **modern tools** of petroleum and geophysics – plate tectonics principles, seismic sequence stratigraphy, gravity and magnetics, well log analysis, geochemistry, petroleum engineering, etc. While the creative mind is still the most important part of the exploration process, advanced tools of perception that let us "see" into the subsurface and remotely define its attributes are becoming more important.

- Fluency with the global internet and data searches are now an important part of the skill set.

- Constant learning and intense curiosity about how a sedimentary basin "works" are key attributes of an oil finder.

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Slide 6. I would stress that there are many kinds of minds that find oil and gas, but they commonly have one thing in common: They think of the subsurface realm under their feet as a live, active high-pressure/temperature world – they think of the subsurface realm as a kind of slow-moving atmosphere where the fluids move in geologic time.

For example, this is a cartoon of the atmosphere out to the troposphere – where it moves the fastest; then below that, the flows in the ocean, such as the world-wide thermal-hyaline currents move more slowly – then, the ground water realm that moves in days or months – then below that, the subsurface realm down to maybe 50,000 feet in the sedimentary basins moves even slower -- in geologic time. Finally - the convection cells of the deep Earth keep the oceanic lithosphere and crust spreading and the continents moving.
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Slide 7. If we look at this realm of a salt dome rising buoyantly through the sediments and the fluid motions and heat convection, it **is** a subsurface atmosphere.

There are thousands of characteristics an oil hunter likes to see in his or her basin. For example, salt is a welcome addition that helps the odds in many ways. Understanding the role of salt is TACIT KNOWLEDGE – it builds in one's mind over time. It is non-linear and not an exact science.

Salt movement causes "emergent features" that are caused by 3, 4, or 5 things happening to and influencing each other's character.

Why do we like salt in this subsurface atmosphere?

1. It transfers heat from hot to cold and keeps source rock "in the maturation window."
2. It furnishes conduits for flow up the sides of the salt dome.
3. It forms anhydrate seals that cap oil.
4. It forms traps that stay high throughout their growth – a forgiving environment. Play the forgiving environment – the unknown, unknown's (UNK-UNK's) can actually help you "luck into" something, but first you have to have the picture in your mind!

Once this mental model has been developed and the genetics of this particular basin are established, an endless number of "prospects" pop into one's mind – a crestal graben play, cap rock trap, sub-salt sill plays, etc. ---.

- The mental model of sedimentary basins envisioned here is that basins are complex, non-linear, self-organizing, dynamic natural systems. They are thrown in and out of thermodynamic and pressure equilibrium and experience both positive and negative feedback as they attempt to maintain equilibrium throughout their unique evolution.

- The fluids (oil-gas-water) are the most unstable and mobile parameters of sedimentary basin systems and are the major agents in self-organization in the maintenance of equilibrium.

- Petroleum exploration is the science and art of envisioning multiphase fluid and rock interactions envisioned through time in a high-pressure and temperature environment of the subsurface atmosphere.

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Slide 8. Describing the Human Characteristics of Successful Explorationists I have known is difficult because each person hunts for oil within his or her own mind, but shown here are some traits I have observed.
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Slide 9. With 3-D seismic and attribute analysis, we can strip away layers and "walk in the subsurface." Here the geologist and petroleum engineer are standing upon the reservoir 10,000 feet below the surface and deciding how to drain the various pools as their team of experts helps them.
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Slide 10. Tools of perception like this logging tool are like space ships going into the subsurface realm and telling us what is going on. What a joy to be able to read the language it speaks to us as it visits places 20,000 feet below the surface.
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Slide 11. Rigs are moving into water depths beyond 7,000 feet and drilling to great depths. What a time to be an exploration geologist or engineer. What a joy to land in a helicopter on these marvelous pieces of engineering and be part of the oil business!
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Slide 12. In a short 5-10 years, a large percentage of our explorationists will be retiring and there will be a tower or shift change. What a great time to be moving into the business! But also a huge responsibility to actually find and produce oil and gas for our civilization.
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Slide 13. Here we see the peak in the work force. The oil finders leaving have a responsibility of passing on their skills and traditions. Those taking over will have to learn fast and make major decisions early in their careers.
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Slide 14. I can imagine no more exciting business to be in. The double high of figuring out:

1) Nature's geologic secrets and
2) Finding one of the world's most valuable and needed resources and working with some of the best people who are some of the most interesting characters in the world.

Where else could I have worked with people I so admire?
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References

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National Petroleum Council, 2007, 2008, 2009, Facing the Hard Truths about Energy: A Comprehensive view to 2030 of global oil and natural gas, 388 p. (in hardcopy and CD) (also http://www.potomacenergyprojects.com/web%20ppt%20info/hard%20truths%20about%20energy.ppt) (accessed December 2, 2009).