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Shale Oil and Gas

By: Larry Koepplinger

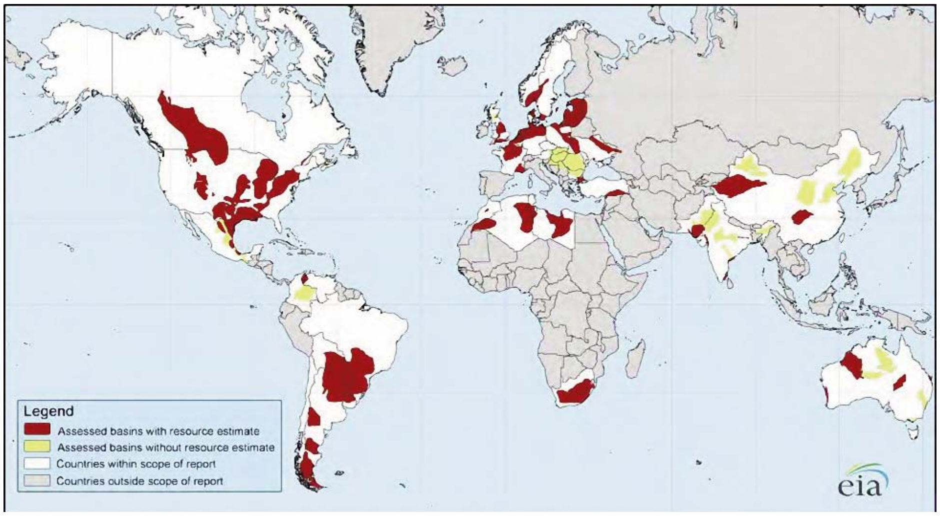

Figure 2

In Houston and in the world offices of many energy-focused companies, shale oil and gas have been active recent news topics. There has been much speculation on Wall Street on the value of these commodities. Driving much of the speculation are unsettled political conditions in many of the world's conventional oil-producing areas and a growing demand for energy among emerging economies. Vast fortunes have resulted, sometimes nearly overnight. Shale resources are fueling the boom conditions in the oil & gas industry. In certain parts of the U.S., mineral rights exceeding $25,000 per acre have turned many struggling farmers into instant millionaires. The special mineral resource creating the boom is oil shale.

Oil Shale "The Rock That Burns"

Shale oil and gas come from shale that contains minute deposits of hydrocarbons; hence it is called oil shale. The oil and gas that results from the oil shale are considered unconventional because the methods to produce them are not like the conventional methods that have served the petroleum industry for more than 150 years.

Oil shale is an ordinary-looking sedimentary rock (Figure 1) that could be mistaken for limestone or chunks of concrete. It contains bituminous petroleum-like material called kerogen, which is a mixture of organic compounds and is a natural result of the chemical breakdown of formerly living organisms. The breakdown process is the opposite of photosynthesis. The formation of kerogen is similar to the natural process of petroleum formation. When kerogens are present in shale formations, they form possible sources of gaseous and liquid hydrocarbons. Under certain conditions of heat or pressure the kerogen will be chemically transformed and release a wide range of combustible hydrocarbons that behave very similarly to petroleum.

Figure 1

The story is told of one of the early discoveries of oil shale in the western U.S. One summer a cowboy built a cabin in the Rocky Mountains. To make sure his cabin would be snug and comfortable for the coming winter, he built a fireplace out of local rocks, properly mortaring them in place. At the first frost of autumn, he built a roaring fire in the fireplace which caught fire and burned the cabin to the ground.

Where It Is/History

Oil shale and its products have been utilized for many centuries. To seal seams on boats and canoes, early man used bitumen (tar) from natural sources, perhaps oozing from the stones ringing their firepits. Herodotus said that bitumen was used as mortar in the walls of ancient Babylon. Mineral oil for medicinal purposes

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and fuel was produced commercially from shale in Germany as early as the mid-seventeenth century. The first patent for the extraction of oil from shale was issued in England in 1694. Because whale oil could not satisfy the demand for lamp oil, an active shale oil industry to produce lamp fuel developed in France in 1838 and thrived until Colonel Drake's 1859 discovery in Pennsylvania of a new method to produce crude oil.

Oil shale can be found in many parts of the world. The U.S. Energy Information Administration map (Figure 2) shows there are major commercial formations in Brazil, northern Europe, China, South Africa, and Australia. More are being discovered every day. There are vast areas of Africa and Asia that have yet to be explored.

Several large geologic formations in North America comprise the largest known deposits of oil shale. There is so much here that the U.S. has been described as the Saudi Arabia of oil shale. Just one formation, the Green River Formation (Figure 3), covers parts of Colorado, Utah, and Wyoming. Estimates of the oil resource in place within the Green River Formation are as much as 1.8 trillion barrels of oil. The estimated recoverable portion of that oil is 800 billion barrels, or more than three times the proven reserves of Saudi Arabia.

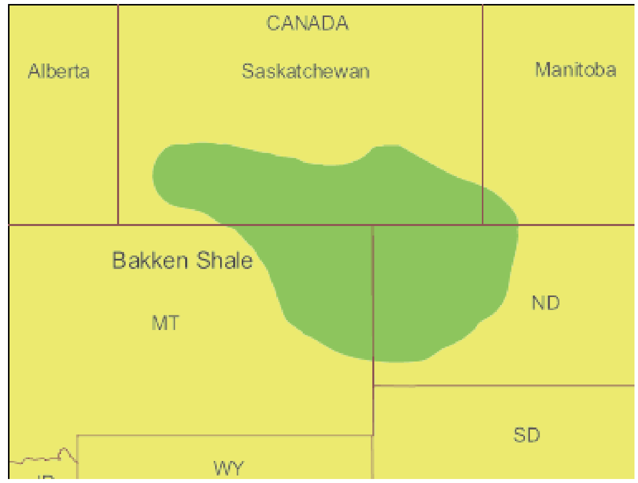


Figure 4

The Bakken Formation (Figure 4) located mostly in North Dakota, Montana, and Saskatchewan may contain over 400 billion barrels.

In the counties in and near Fort Worth and Dallas and a mile or so beneath DFW Airport, the Barnett Formation may contain 2.5 trillion cubic feet of natural gas.

The Haynesville Formation (Figure 5) in Louisiana and East Texas may be the largest natural gas field in the contiguous 48 states. It may contain 250 trillion cubic feet of recoverable natural gas.

The Eagle Ford Formation covers two dozen or so counties east and south of San Antonio, Texas and down to the Mexican border. It is of particular interest because it contains deposits rich in natural gas liquids (NGL). NGLs fetch a higher price in the marketplace relative to natural gas for a variety of market-driven reasons.

Marcellus Shale (Figure 6) is found in West Virginia, Pennsylvania, New York, and eastern Ohio. It is prized for its liquids-rich deposits that are near existing delivery pipelines and the high energy demand population centers of the east coast.

More recent shale discoveries that are now being explored include Fayetteville, Uinta, Niobrara, Woodford, and Utica. These are names we will be hearing more about in the future.

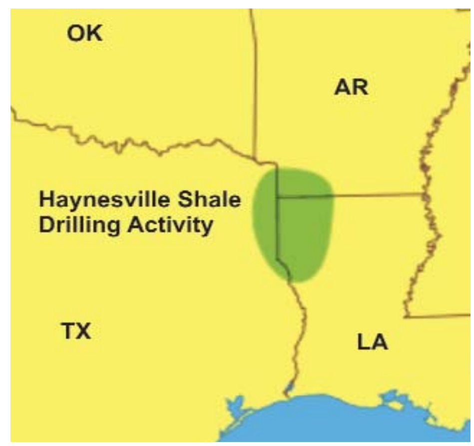


Figure 5

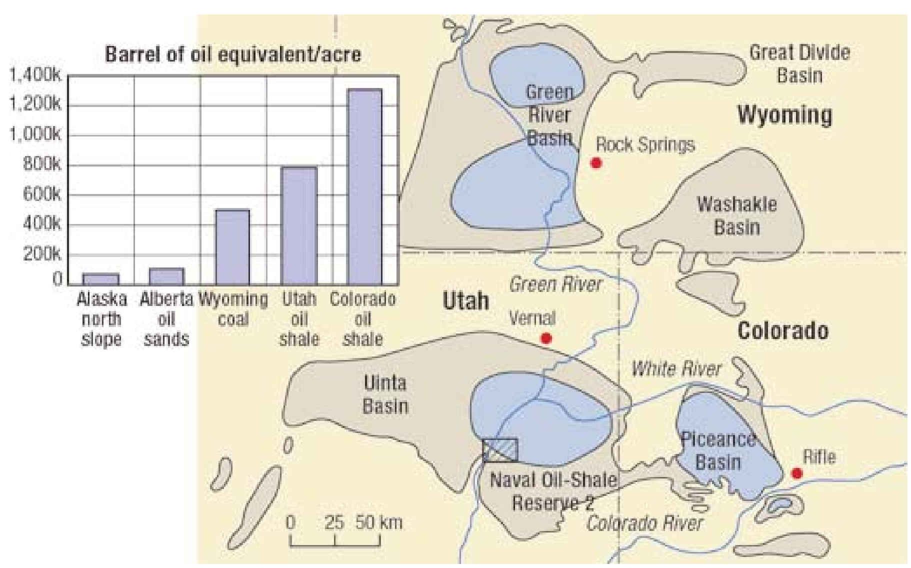


Figure 3

The Natural Gas/Crude Oil Price Relationship

In all shale oil formations, both gas and liquids will be found, but all formations have more gas than liquids. Some formations tend to produce mostly gas with few liquids, Haynesville and Bakken for example. Some formations produce somewhat higher percentage of NGLs, like Eagle Ford and Marcellus.

Liquids-rich formations are prized for

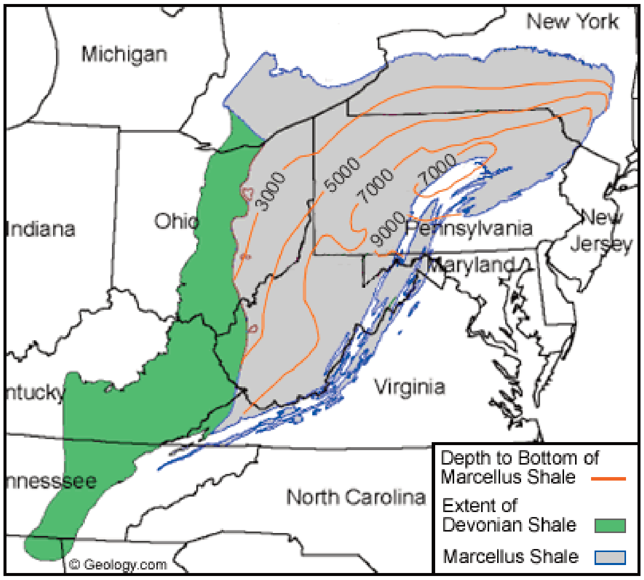


Figure 6

two main reasons. Because of their liquid form, NGLs have a higher volumetric energy concentration than natural gas. Additionally, NGLs are more easily transported than natural gas. For these and other reasons the price of NGLs tends to be influenced more by the price of a barrel of crude oil than by the price of natural gas.

A barrel of crude oil has approximately six times the energy content of one thousand cubic feet (1 mcf) of natural gas. Crude oil has recently sold at about $100 per barrel. On an equivalent energy basis, 1 mcf of natural gas should cost about one sixth of a barrel of crude oil, or about $16. Natural gas is currently selling for about $4 per mcf. Compared to the price of crude oil, natural gas is a relative bargain. The value proposition of natural gas versus crude oil has not been missed by the major players in the oil industry. In the last few years, virtually every major oil and gas exploration company has taken an investment position in gas shale. The upside potential is too great to ignore.

Since petroleum is a global commodity, its price is driven by world demand. The growing hunger for energy to fuel emerging economies in China, India, and elsewhere is almost certain to maintain upward pressure on the price of oil.

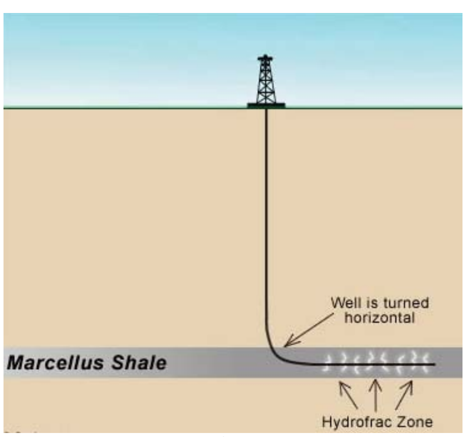


Figure 7

Because natural gas is less convenient to transport than liquid oil, natural gas prices tend to be influenced less globally and more regionally. The present abundance of natural gas in this country helps to explain why natural gas prices are depressed. But perhaps not for long. Aging coal-fired powerplants are being converted to burn natural gas because natural gas combustion

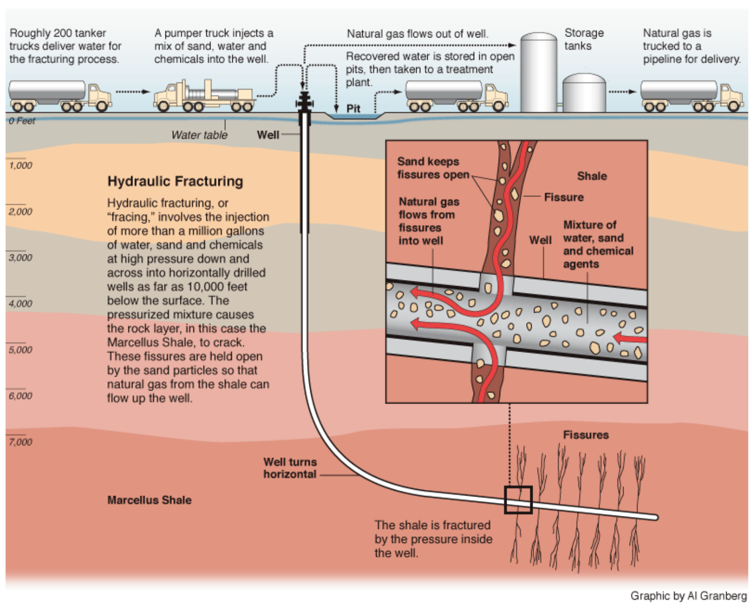


Figure 8

creates fewer emissions. The recent earthquake and tsunami disaster in Japan has largely quelled discussion of nuclear power plants. Germany plans to close all of its nuclear plants by 2022. Automobile and truck manufacturers are constantly seeking more efficient and cleaner powerplants.

Many fleets of urban mass-transit buses are being converted to run on compressed natural gas. Future demand and uses for natural gas will likely increase.

Technologies for Oil Recovery

With all the oil shale deposits around the world, we should seemingly have an abundance of cheap oil and gas. Unfortunately the shale yields its oil only grudgingly. Oil from shale can be recovered by several methods. Some of the oldest historical recovery methods employ open mining of the shale, especially where the shale is located close to the surface. In Estonia, the shale is burned as it comes from the mine to generate the majority of that country's electricity. Open-pit and deep mining create many environmental and ecological challenges.

To recover the kerogen from the mined shale, it must be heated to nearly 700 degF in an oxygen-free atmosphere. The industrial process equipment to accomplish this is called a retort. After the kerogen is liberated from the shale, it is collected for further processing, similar to crude oil. The oil-depleted shale represents a significant disposal problem.

A process called in situ retorting involves heating the oil shale while it is still underground and then pumping the resulting liquid to the surface. The advantages of this process is that it eliminates both the cost of handling the shale to the surface (from perhaps more than 2 miles down) and disposal issues for the processed shale. The land surface remains unchanged. However, heating the shale miles underground is expensive and technically challenging.

Although the existence of large shale deposits containing hydrocarbons has been known for many decades, until relatively recently it was thought that recovery of the hydrocarbons was uneconomical. The integration of two technologies has been the driving force in the rapid growth and expansion of the shale oil industry as it is known today. The two technologies most responsible are directional drilling and hydraulic fracturing.

In a conventional petroleum recovery process the gas or oil well is drilled down to the pocket of resources which exist in

Figure 9

large volumes and huge cavities in the earth's crust. In shale formations, the resources typically exist in wide, but shallow horizontal seams that run for many miles. Drilling multiple, perhaps hundreds, of wells down to a shallow seam of shale would be prohibitively expensive.

In directional drilling (Figure 7), the well is drilled down to the seam and then turned to drill horizontally into the seam. One well can accommodate multiple horizontal branches.

After the directional well is drilled, hydraulic fluid under high pressure and containing a proppant (usually sand) and water is pumped into the seams to hydraulically fracture the seam of shale. This process is called fracking (Figure 8). The pressurized hydraulic mixture causes the shale seams to open, crack and create additional fissures. The purpose of the proppant is to prop and hold the fissures open. From these fissures the gas and liquid resources are collected and sent to the surface for processing and treating.

NELSON Experience

NELSON has participated in a number of projects aimed at developing technologies to allow recovery of hydrocarbons from oil shale. Most of these projects were located in the Piceance Creek area of NW Colorado, and included design of pilot plants for demonstration of in situ pyrolysis processes (Figure 9), as well as environmental containment systems based on Freeze Wall Technology (FWT). The FWT process (Figure 10) involves establishment of a barrier freeze wall around the perimeter of an extraction zone. The produced oil (kerogen) is extracted from the heated volume.

The freeze wall is created by pumping refrigerated fluid through a series of wells drilled around the extraction zone. The freeze wall prevents groundwater from entering the extraction zone and keeps the generated hydrocarbons from escaping the project perimeter.

NELSON has completed unconventional gas and oil recovery projects in Barnett Shale and Haynesville, as well as substantial project experience providing surface processing of the collected liquids and gases. The processing experience includes gas and liquids gathering, treating, processing, and compression, as well as design of storage systems, pipeline connections and facilities.

Future for Shale Oil and Gas

In 2008 approximately 11 percent of U.S. natural gas was from shale gas sources. By 2035, shale gas is expected to provide nearly 50 percent of our needs. Shale gas and oil is a creative way to increase our country's domestic energy reserves while reducing dependence on foreign supplies.

In spite of the glowing potential for shale oil, some significant challenges remain. Hydraulic fracking is a water-intensive process. Only a small percentage of the water used is recovered. To frack a well in Barnett Shale may require up to 3 million gallons of water. In the complex geology of Eagle Ford Shale the water required may be up to 13 million gallons. Most of the state of Texas is enduring drought conditions that are the worst in over a century.

Recent concerns by landowners over potential ground water contamination have caused manufacturers of fracking fluids to voluntarily disclose the proprietary chemicals used. Fracfocus.org was established as a forum for companies to make their disclosures. In some cases the chemistry of the fracking fluid was modified to be more benign. Some gas wells have been blamed for poor structural integrity, causing gas to escape control and leak methane into nearby water wells. Clearly more conscientious application of state, regional, and industry controls will be mandated.

As we probe deeper into the earth's crust to exploit resources, new challenges will present themselves. With proper industry oversight and a commitment to good stewardship of our environment, technologies to release the bounty offered by oil and gas shale will serve the growing energy needs of our planet for centuries to come. The technical professionals of NELSON stand ready to serve our customers in this worthy pursuit.

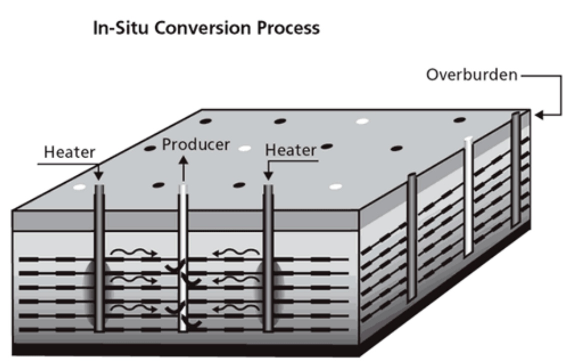


Figure 10

NELSON ENGINEERS WERE ONBOARD THE FINAL SHUTTLE FLIGHT

The pilot for the Space Shuttle's final flight, Douglas G. Hurley (COLONEL, USMC), a Tulane University Civil Engineering graduate, carried the names of all Tulane Civil Engineering graduates from 1900 to 2007 with him when he blasted off on the final Shuttle flight. By our count there were over 30 of NELSON's current and past employees on that list, ranging from Robert Atkinson (1920) to Bridget Kelly (2007), a member of Tulane's last graduating class of civil engineers.

The list of current NELSON employees who traveled on the final Shuttle flight (in name only) included Jerry Hanafy, Jesse Hemeter, Steve Johns, Bridget Kelly, Jim Lane, Pete Olivier, Glenn Richoux, and Brad Rogers.

Also along for the ride were past company officers, Robert Atkinson, Col. Victor Bedell (co-founder of our company), Bill Becnel, Lew Bremenstul, Ronnie Cressy, David Hebert, Dale Hunn, Sam Landry, and Joe Stassi.

NELSON's feet have been planted in space since the early days of the space program. We have designed more than 60 projects going back to the 1960's supporting the space program for Martin Marietta, Chrysler, and NASA. Some of the projects include designing the external tank's Ablator Spray Cell building, major modifications at Michoud (in New Orleans East) required for the Apollo and Shuttle programs, bridges and docking facilities at the Stennis Space Center (in southwestern Mississippi), a study for the Space Shuttle vehicle runway, numerous upgrades and modifications at Michoud and Stennis, and many studies and environmental reports.

Dr. Peter Smith Retires

Patty and Pete Smith

Dr. Peter Smith, Senior Vice President and Manager of our Environmental Sciences and Engineering Department, retired from full time service on March 31st, 2011. "Pete" graduated from Louisiana State University with a B.A. in Chemistry in 1970. He continued his studies at Tulane earning both his Masters in Environmental Sciences degree in 1971 and his Sc. D. in 1976. Having several publications to his credit attested to his intellectual ability and serious commitment to his profession. He began at NELSON on November 16, 1976, was made Manager of our Environmental Department early in 1977 and was elected to the position of Assistant Vice President in 1978. He was promoted to Vice President in 1985 and then Senior Vice President in 1991.

Chairing a department with a wide range of projects, Pete oversaw air and water quality monitoring, stack testing, industrial wastewater treatment, and municipal and industrial solid waste handling and disposal projects. He also managed the all-important permitting services required by our clients. He worked closely with state regulatory agencies in multiple states, and with federal agencies such as the EPA, Corps of Engineers, Minerals Management Service and other federal and state resource agencies. Widespread asbestos abatement inspection and supervision projects kept him and his staff busy in the '80's.

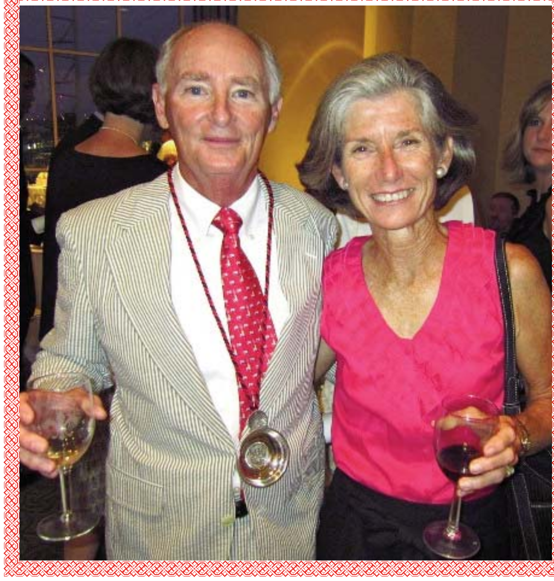
In addition to his client and corporate duties, Pete found time in the 1978-1982 period to teach graduate level courses in air pollution as an adjunct professor at Tulane University, returning as a Clinical Associate Professor in 2001-2003 teaching graduate courses in environmental remediation. In the aftermath of Hurricane Katrina in 2005, Pete recruited and managed a group of 30+ engineers, technicians, displaced students and inspectors to assist in the housing of hundreds of Louisiana residents in FEMA – supplied trailers, earning high commendation from FEMA for his performance in that program.

In his retirement, Dr. Smith has committed to continue several special projects for the company where his experience and expertise in coastal wetlands restoration will be part of Louisiana's ongoing efforts to strengthen and rebuild our coastline.

Matt Smith, Kristen Smith Cahoon and Dann Cahoon

Charles Nelson and Karen Eigenbrod

l: Pete with Ginger Dodge presenting him with his new job poster.



At the French American Chamber of Commerce Louisiana (FACC/LA) 2011 Summer Wine Festival, Mr. Robert Olivier, AIA, pictured above with his wife Barbara, was inducted into the prestigious Confrérie du Vin de Surensnes (Brotherhood of the Wine of Suresnes), one of the oldest wine societies in France. Robert serves on the Board of the FACC/LA as Treasurer.

Nelson New Orleans employees raised money participating in a lunch time BBQ, Bake Sales and Volleyball Tournament for New Orleans Children's Hospital.

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