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Gary B. Glass, State Geologist

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THE GEOLOGICAL SURVEY OF WYOMING

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WYOMING GEO-NOTES

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Front cover: This is not an EKG, an electric log lying horizontal, or Reddi Kilowatt's logo. It is a plot of recent oil prices. The details, including a caption and labels, are found inside on page 4.

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MINERALS UPDATE

OVERVIEW

by Gary B. Glass, State Geologist and Director, Geological Survey of Wyoming

With half a year's production already available, it is fairly safe to predict that Wyoming will remain Number One in coal production again in 1989. Production in 1989 should be very close to 170 million tons, or more than a six million ton increase over the record 163.6 million tons mined in 1988. Looking farther into the future, annual production should be close to 200 million tons by 1995 (Table 1).

While these production increases bode well for employment stability and payrolls in the coal mining industry, they have a downside in regard to State and county revenues. Because all these forecast increases in production are related to new contracts or spot sales, the prices received for these sales have all been well below $4.00 per ton. Even renegotiated contracts are coming in at similar prices. The tonnage increases, though substantial, are not enough to offset the effect of the lower prices, at least through the middle of the next decade. The bottom line is that as coal production increases in the Powder River Basin, the lower prices received for this coal will decrease the average assessed value per ton; thereby decreasing revenues from severance and ad valorem taxes as well as from royalty payments.

Increases in coal prices seem unlikely before the late 1990s because of the excess production capacity in the Powder River Basin. By the late 1990s, the surplus coal-producing capacity should be gone or waning. Coal prices could possibly rise sooner than the late 1990s if production increases substantially more than we have predicted or if oil and gas prices increase significantly. While the former is a real possibility, the latter seems unlikely.

Natural gas production is also increasing each year now as the "gas bubble" of the past several years disappears (Table 1). Increased demand for gas is opening heretofore shut-in wells more and more frequently each year. While there was a time not long ago that many smaller gas producers in the Powder River Basin were seeking permission to flare unwanted gas, that is no longer the case. In fact, there is enough demand that several large coalbed methane projects are coming on line and finding a ready market for their new production. Companies drilling new gas wells in the Green River Basin of southwestern Wyoming are not only betting on a new pipeline to California, but also on other new markets to include the Midwest.

Here again, like coal, the only downside is the sale price for much of the gas. Many forecasters predicted significant increases in gas prices with both deregulation (which is now a fact) and with the bursting of the "gas bubble". Significant price increases, however, have not occurred yet. In part, this may be the result of the "gas bubble" only leaking slowly rather than bursting quickly. It does look like natural gas prices bottomed out in 1988 and 1989 and therefore will continue to increase yearly. This will help the gas industry and should stimulate even more drilling.

Table 1. WYOMING MINERAL PRODUCTION FORECAST TO 1993[1].

Calendar Year	Oil Production[2]	Methane Production[3]	Carbon Dioxide Production[3]	Helium Production[4]	Coal Production[5]	Trona Production[5]	Mined Uranium Production[6]	In situ Uranium Production[7]	Sulfur Production[8]
*1981	122.1	455.4	—	—	102.8	11.8	4.6	—	0.05
*1982	118.7	465.1	—	—	107.9	10.1	2.1	—	0.07
*1983	120.9	539.7	—	—	112.2	10.5	3.0	—	0.57
*1984	127.8	600.1	—	—	130.7	11.0	1.6	—	0.63
*1985	131.0	597.9	—	—	140.4	10.8	0.6	—	0.80
*1986	122.4	563.2	23.8	0.15	136.3	13.3	0.3	—	0.66
*1987	115.9	622.7	110.5	0.84	146.5	13.6	0.2[9]	0.06	1.20
*1988	114.3	701.1	110.5	0.84	163.6	14.9	0.3	1.4	1.20
1989	108.0	704.5	110.5	0.84	170.0	15.0	0.2	2.0	1.20
1990	103.6	729.0	110.5	0.84	177.1	18.0	0.2	2.0	1.20
1991	98.1	754.1	110.5	0.84	183.8	18.0	0.1	3.0	1.20
1992	92.9	780.1	110.5	0.84	189.2	18.0	0.1	3.5	1.20
1993	88.0	806.8	110.5	0.84	193.1	21.0	0.1	4.0	1.20

*Actual values for comparison; [1]Geological Survey of Wyoming, October 1989; [2]millions of barrels; [3]billions of cubic feet; [4]billions of cubic feet, based on Exxon's estimate that the average helium content in the gas processed at Shute Creek is 0.5 percent; [5]millions of tons; [6]millions of tons of uranium ore (not yellowcake); [7]millions of pounds of yellowcake (U_3O_8), (unknown between 1981-1986 because it was reported only as taxable valuation; estimates for 1989-1993 are based on company information); [8]millions of tons, converted from gallons of sulfur produced at gas processing plants as reported to the Wyoming Oil and Gas Conservation Commission; [9]includes previously stockpiled ore processed by the Lucky Mc mill in 1987.

Before discussing some positive signs in the trona and uranium industries, something needs to be said about oil production. Production did decline between 1987 and 1988, but not as much as some anticipated (Table 1). The slowing of the decline is attributed to some rather large tertiary recovery operations, which came on line. Unfortunately the decline of the older larger fields will very likely overcome incremental increases from tertiary projects in 1989 and beyond, and production will begin to decline at about five percent or more per year.

Oil prices are another matter and one of some relief. The price for Wyoming oil has stayed above $17.25 for the last seven months. While prices have not been up there long enough or high enough to stimulate an increase in exploration, these prices are a far cry above the disastrously low prices of last year.

As mentioned earlier, there is optimism for trona as two soda ash companies had announced expansion plans by the end of the third quarter. Soda ash production is running at or near capacity in all five plants and production is forecast to increase in 1990 and again in 1993. Although uranium prices have fallen, existing, *in situ*, uranium solution mines are proceeding to expand their production also, and several newcomers are still moving forward with their plans for new solution mines.

In regard to other mineral activities in the third quarter, there is still keen interest in opening a glass plant in the State and making that glass from raw materials all

derived from Wyoming. Some interest in garnet and mica deposits has surfaced, and gold placer mining is increasing along with exploration for several other metals.

Overall the third quarter has brightened the prospects for increased production of mineral and energy resources with the exception of oil. In the case of oil, however, the higher and more stable price is a good sign that was hard to reliably predict.

Table 2. PRODUCTION HISTORY OF SELECTED WYOMING MINERAL COMMODITIES[1].

	1980	1981	1982	1983	1984	1985	1986	1987	1988
Ballast[2,3]	1.65	1.72	0.81	0.99	2.43	0.67	0.61	1.09	NA[7]
Bentonite[2]	3.58	4.81	2.35	2.18	3.08	2.59	1.82	2.16	2.32
Clay[4]	42.0	23.2	15.7	36.4	59.6	35.9	23.2	1.31	NA
Decorative Stone[2]	0.05	0.05	0.05	0.07	0.08	0.09	0.07	0.06	NA
Dolomite[2]	1.67	0.87	0.61	0.66	0.86	0.87	0.81	0.46	NA
Feldspar[4]	0.20	0.03	0.17	----	----	----	----	----	----
Gypsum[2]	0.30	0.28	0.26	0.33	0.33	0.35	0.41	0.35	NA
Iron Ore[2]	4.88	4.67	3.28	2.48	----	----	----	----	----
Limestone[2,5]	0.50	0.72	0.59	0.56	0.65	0.32	0.34	0.42	NA
Sand and Gravel[2]	5.06	5.21	4.74	5.00	4.76	4.71	3.53	2.57	2.16
Scoria[2,6]	0.03	0.08	0.08	0.07	0.23	0.13	0.04	----	NA
Shale[4]	----	----	----	----	20.3	14.7	9.88	0.49	NA
Sodium Sulfate[4]	----	3.20	3.17	3.19	3.25	2.71	2.03	----	NA

[1] Source: Ad Valorem Tax Division. [2] Millions of short tons. [3] Includes granite, scoria and other rock. [4] Thousands of short tons. [5] Includes limestone used for cement rock, sugar beet refining, and other uses. [6] Baked and fused rock, also called clinker [7]NA means not available. Prepared by Geological Survey of Wyoming, October, 1989.

OIL AND GAS UPDATE

by Rodney H. DeBruin, Oil and Gas Division Head, Geological Survey of Wyoming

Several signs indicate renewed vigor in Wyoming's gas industry. Final figures from the Wyoming Oil and Gas Conservation Commission show that 811.6 billion cubic feet of gas were produced in 1988, an increase of 10.7 percent over 1987 production. Table 1 gives a breakdown of that production, i.e. methane versus carbon dioxide gases.

The average monthly rig count, which was stagnant for the first four months of 1989, finally began to rise at a rapid rate. September's average was the highest since December, 1987 (Figure 1). Most of the increase in the count are related to more gas wells being drilled. Forecasters are predicting an end to the gas deliverability surplus ("gas bubble") this winter and some predict a gas deliverability crisis in the near future. Even though posted crude oil prices have been between $17.25 and $19.50 for the last seven months (Figure 2), prices have not remained stable long enough to stimulate increased rates of oil drilling.

Figure 1. WYOMING RIG COUNT AVERAGED BY MONTH (1982 TO PRESENT).

Figure 2. WYOMING CRUDE OIL PRICES AVERAGED BY MONTH (1987 TO PRESENT).

In addition to the infill drilling planned by Union Pacific Resources and Enron Oil and Gas (*Wyoming Geo-notes No. 22*, page 4), WEXPRO has completed several new gas wells and has five rigs under contract for an extensive gas development program in the Church Buttes Field area. It's no coincidence that these three projects are all in southwestern Wyoming. All three are betting at least in part on an Opal to California pipeline.

In regard to the Opal to California pipeline, both WyCal and Kern River signed more transportation commitments. WyCal has even bought 450 miles of large-diameter pipe. Kern River Transmission Co. reached an agreement with Southern California Gas Co. and with Mojave Pipeline Co. that ended a four-year dispute. Under terms of the agreement, Kern River would build their line from Opal, Wyoming and Mojave would build their line from Topock, Arizona. The lines would merge near Barstow, California and continue as a single line for another 200 miles to Kern County's oil fields. Kern River reached an earlier agreement with Altamont, a Canadian consortium, that paves the way for transporting Canadian gas from Wildhorse, Alberta, Canada to Opal, Wyoming on a pipeline that would merge with Kern River's pipeline (*Wyoming Geo-notes No. 23*, pages 5-6).

Another good sign for Wyoming gas producers concerns the Trailblazer Pipeline. Although Trailblazer was built to move gas from the Overthrust Belt to the Midwest, in recent months it has only moved about 150 million cubic feet of gas per day. Trailblazer's capacity is 350 million cubic feet of gas per day. A new proposal would cut shipping charges on Trailblazer by at least half. Regulatory approval of the proposal might mean that an additional 200 million cubic feet per day of Overthrust Belt gas would move to the Midwest.

President Bush recently signed a gas price decontrol bill. The law removes controls on the remaining natural gas that is subject to price ceilings. Controls will end by January of 1993 for existing wells and by May of 1991 for wells drilled after the bill was signed. Although short term effects of the bill will probably not be dramatic, price increases for Wyoming producers should be realized as gas supplies dwindle.

Uinta County is a potential site for a very large ethylene and ethylene-derivative plant in the mid-1990s according to a study conducted for Uinta County by Chem Systems Inc. An ethylene plant could use natural gas liquids from eight gas processing plants already located in the County. According to a spokesman for Chem Systems, a plant in production by 1993 would provide employment for about 520 people, would yield projected revenue estimated at $400 million, and could produce one billion pounds of chemicals per year.

Many of the higher bids at the last two oil and gas lease sales held by the Wyoming Department of Public Lands and the last sale held by the U.S. Bureau of Land Management (BLM) were for leases in the predominantly gas-producing Green River Basin.

Table 3. FEDERAL AND STATE COMPETITIVE OIL AND GAS LEASE SALES IN WYOMING

BLM SALES

Month	Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre
				1987			
TOTAL	$15,724,159	727	646	197,422	177,960	$ 88.36	$6,555.00
				1988			
March	$7,338,210	866	336	1,073,940	315,387	$23.27	$525.00
June	$7,564,135	820	375	755,242	293,050	$25.81	$575.00
August	$5,827,548	847	363	827,471	278,198	$20.95	$1,350.00
October	$3,913,765	820	257	994,618	282,145	$13.87	$6,500.00
December	$3,045,203	766	260	761,242	182,117	$16.72	$330.00
TOTAL	$27,688,861	4,119	1,591	4,412,513	1,350,897	$20.50	$6,500.00
				1989			
February	$2,418,295	800	230	857,475	187,012	$12.93	$1,225.00
April	$2,334,604	732	227	557,643	145,055	$16.09	$390.00
June	$1,673,150	758	163	962,929	138,691	$12.06	$160.00

STATE SALES

Month	Total Revenue	Number of parcels offered	Number of parcels leased	Total acres	Acres leased	Average price per acre leased	High price per acre
				1987			
TOTAL	$2,526,567	1,200	579	511,638	244,740	$10.32	$2,300.00
				1988			
January	$826,698	200	142	76,953	56,430	$14.65	$200.00
March	$800,213	200	133	76,304	48,423	$16.53	$465.00
May	$1,649,974	200	182	75,987	69,285	$23.81	$290.00
July	$1,855,646	200	155	77,168	60,519	$30.66	$375.00
September	$751,646	200	142	68,456	55,168	$13.63	$180.00
November	$318,547	200	119	71,085	42,118	$7.56	$130.00
TOTAL	$6,202,724	1,200	873	445,953	331,943	$18.69	$1,640.00
				1989			
January	$331,145	200	112	73,322	39,650	$8.35	$110.00
March	$493,179	200	129	74,512	47,886	$10.30	$140.00
May	$512,736	199	129	76,396	51,919	$9.88	$155.00

Sources: Wyoming Department of Public Lands, Petroleum Information Corporation - Rocky Mountain Region Report, and U.S. Bureau of Land Management.

Lease sales in the State did well during the third quarter of this year (Table 3). The high per-acre bid at the August BLM sale was $285 by High Plains Energy for a 280-acre lease in section 29, T.23N., R.110W. The tract is nearly four miles south of shut-in Dakota and Frontier production at Four Mile Gulch Field. Celsius Energy and Union Pacific Resources bid $294,000 ($115 per acre) for a 2,560-acre lease which included sections 22, 23, 24, and 25, T.15N., R.95W. The tract is five miles northwest of Dripping Rock Field. Dripping Rock Field has produced over 7.5 billion cubic feet of gas from the Almond and Lewis since it was discovered late in 1984.

The high bid at the Wyoming Department of Public Land's July sale was $190 per acre by Exxon Corp. for a 640-acre lease covering section 36, T.23N., R.111W., three miles southeast of Frontier gas production at Storm Shelter Field. Maurice W. Brown made the high per-acre bid of $540 at the August sale for an 80-acre lease in section 11, T.50N., R.71W. The lease is two miles northwest of Minnelusa production at FD Field and about a mile and a half southeast of Muddy production in Springen Ranch Field.

Not all of the increased gas activity is taking place in southwest Wyoming. Coastal Oil and Gas Corp. has drilled several coalbed methane wells in their Sasquatch Unit in T.47N., R.77W. and T.48N., R.77 and 78W. in the Powder River Basin. Coastal plans to drill a total of 20 to 30 wells in the next 18 months. Gilmore Oil and Gas staked four coalbed methane tests just a few miles north of Coastal's unit. BETOP is also staying active in the Powder River Basin's coalbed methane play. They staked nine new locations in Campbell County; most of the locations are in Dead Horse Creek Field in T.49N., R.75W. Conquest Oil staked two tests of Ferris Formation coal seams in the Hanna Basin. One of the tests will be in section 30, T.24N., R.83W. and the other in section 23, T.23N., R.83W.

DeBruin and Jones (1989) estimate that the resource of in-place coalbed methane in Wyoming is between 7.25 and 145 trillion cubic feet. The more conservative estimate of this resource is one third as large as the current estimate of discovered methane in the entire State (Table 4 on page 10). And that latter estimate does not include any figures for coalbed methane.

Based on company data and on information compiled and published by Petroleum Information, the following significant exploration and development events occurred in Wyoming during the third quarter of 1989. The letters preceding the following discussions refer to locations on Figure 3:

A. Activity in the Overthrust Belt has picked up during the past few months. Exxon reported a discovery which has been named Collett Creek Field. The 1 Collett Creek Unit well in section 19, T.21N., R.118W. (bottom hole location in section 20, T.21N., R.118W.) flowed 601 barrels of 45.6° API gravity oil and 2.11 million cubic feet of gas per day from the Ordovician Bighorn Dolomite.

B. Exxon also scheduled a Bighorn test about three quarters of a mile south of an Exxon Bighorn Dolomite producer in Road Hollow Field. The new well, the 1 Bridger Fork Unit will be drilled in section 4, T.20N., R.119W. Through June, 1989,

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Figure 3. OIL AND GAS EXPLORATION AND DEVELOPMENT ACTIVITY IN WYOMING.

two wells in Road Hollow Field had produced a little over 1 million barrels of oil and 20 billion cubic feet of gas from the Bighorn.

C. Exxon also spudded their 1 Rockslide Unit well in section 12, T.23N., R.118W. to test the Madison Limestone and Bighorn Dolomite. This well is about 15 miles north of significant Bighorn production in the Overthrust Belt.

D. Amoco Production Co. decided not to drill its 1 Sohare Unit well to test the Madison in section 35, T.43N., R.112W. The company cited economic considerations for the cancellation. Amoco estimated the well would have cost $3 million to drill.

E. ANR Production completed a new Dakota producer on the west side of Lincoln Road Field. The 1-24 Raptor Unit well in section 24, T.24N., R.112W. flowed 750,000 cubic feet of gas and 622 barrels of 49° API gravity condensate per day.

F. Lincoln Road Field has another producing Dakota well drilled by Thermal Exploration in section 8, T.24N., R.111W. The 3-8 Raptor Unit well was tested for 241 barrels of condensate and 5.8 million cubic feet of gas per day. Through June

of 1989, Lincoln Road Field had produced nearly 900,000 barrels of oil/condensate and over 30 billion cubic feet of gas. The field produced 220,000 barrels of oil/condensate and 6.15 billion cubic feet of gas through the first half of 1989.

G. Presidio Exploration completed a Frontier extension to Seven Mile Gulch Field. The 1 State of Wyoming/AH well in section 16, T.21N., R.111W. flowed 407,000 cubic feet of gas and 39 barrels of oil per day. The new producer is about two miles northeast of the field discovery completed by Amoco in 1976.

H. WEXPRO Company's development program in Church Buttes Field is yielding some very good results. The 52 Church Buttes Unit well in section 34, T.18N., R.112W. flowed four barrels of condensate and 710,000 cubic feet of gas per day from the Dakota; the 48 Church Buttes Unit well in section 11, T.17N., R.112W. flowed 3.34 million cubic feet of gas per day from the Frontier Formation; the 47 Church Buttes Unit well in section 1, T.17N., R.112W. flowed 1.24 million cubic feet of gas per day from the Frontier; the 57 Church Buttes Unit well in section 9, T.17N., R.112W. flowed 2.91 million cubic feet of gas and 24 barrels of condensate per day from the Dakota; the 46 Church Buttes Unit well in section 3, T.17N., R.112W. flowed 2.02 million cubic feet of gas per day from the Frontier; the 55 Church Buttes Unit well in section 22, T.17N., R.112W. flowed 4.80 million cubic feet of gas daily from the Frontier Formation; and the 63 Church Buttes Unit well in section 18, T.16N., R.112W. flowed 3.42 million cubic feet of gas and 36 barrels of condensate per day. Together these seven new wells flowed 18.44 million cubic feet of gas and 60 barrels of condensate daily. WEXPRO is currently drilling or testing eight additional wells in the area and has staked locations for eight other wells.

I. The Muddy Sandstone is currently being tested in General Atlantic Resources' 23-1 Warren Livestock well in section 23, T.13N., R.68W. in Borie Field. A drill stem test in the Niobrara recovered 1,500 feet of gas and 200 feet of gas-cut oil. The sample chamber contained 1,500 cubic centimeters of mud-cut oil and 0.1 cubic feet of gas. Borie Field produced an average of 462 barrels of oil and 335,000 cubic feet of gas per day in June, 1989. The field has produced nearly 3.1 million barrels of oil and over 675 million cubic feet of gas since it was discovered in 1949.

J. Buck Draw North has another excellent Dakota producer. Kerr-McGee Corp. completed the 31-7 North Buck Draw Unit well in section 7, T.41N., R.73W. The well flowed 2,333 barrels of oil and 3.58 million cubic feet of gas per day.

K. A fourth Minnelusa producer was completed in Widge Field by Union Texas Petroleum. Their 5 Wright 24 well in section 34, T.46N., R.72W. was completed on pump for an initial potential of 60 barrels of 37.2° API gravity oil, 27,000 cubic feet of gas, and 18 barrels of water per day. Widge Field was discovered in 1987 and has produced over 190,000 barrels of oil and nearly 32 million cubic feet of gas through June, 1989.

L. EP Operating was still pump-testing its 32-24 Dunlap well in section 24, T.48N., R.72W. at last report. They recovered 182 barrels of oil on an earlier 18-hour pump-test. The well is a Minnelusa offset to the Ridgeview Field discovery.

Table 4. MINERAL RESOURCE AND RESERVE BASE ESTIMATES FOR WYOMING

PETROLEUM	
Remaining Resources (January 1, 1989)	
Discovered (Includes 10 billion barrels recoverable by enhanced recovery techniques)	12.9 billion barrels[1]
Undiscovered	7.6 billion barrels[1]
Total	20.5 billion barrels
Remaining Reserve Base (January 1, 1989)	
Measured reserves (Proved reserves)	0.75 billion barrels[2]
Indicated and inferred reserves	2.8 billion barrels[1]
Total	3.55 billion barrels
NATURAL GAS	
Remaining Resources (January 1, 1989)	
Discovered (Includes 23 trillion cubic feet (TCF) of methane[1] and 12 TCF of CO_2 and He^3)	35.0 trillion cubic feet
Undiscovered (Includes 58 TCF of conventional methane[1]; 7 TCF of coalbed methane[4]; 3,611 TCF of methane in tight gas sands in the Green River Basin[5]; and 103 TCF of CO_2 and He^3)	3,779.0 trillion cubic feet
Total	3,814.0 trillion cubic feet
Remaining Reserve Base (January 1, 1989)	
Measured reserves (Proved reserves) (Includes 9.9 TCF of methane[2] and 11.8 TCF of CO_2 and He^3)	21.7 trillion cubic feet
COAL	
Remaining Resources (January 1, 1989)	
Identified and Hypothetical (Discovered)	1,431.4 billion tons[6]
Speculative (Undiscovered)	31.5 billion tons[6]
Total	1,462.9 billion tons
Remaining Reserve Base (January 1, 1989)	
Demonstrated strippable (Measured and indicated reserve base)	26.8 billion tons[7]
Demonstrated underground-minable (Measured and indicated reserve base)	38.3 billion tons[7]
Total	65.1 billion tons
TRONA	
Original Resources (1983 estimate)	
Trona	81.7 billion tons[8]
Mixed trona and halite	52.7 billion tons[8]
Total	134.4 billion tons
URANIUM	
Remaining Resource (December 31, 1985)	1.99 billion pounds U_3O_8[9]
Remaining Reserve Base (December 31, 1985)	
Uranium oxide recoverable at $30.00 per pound	83 million pounds[9]
OIL SHALE	
Original Resources (January 1, 1983)	
Identified (Discovered)	320 billion barrels of shale oil[10]

1 Modified from Barlow, J.A., Jr. and Doelger, M.J., 1983, Wyoming mineral resources: Barlow and Haun, Inc., Casper, 14 p.

2 Modified from Energy Information Administration, 1988, U.S. crude oil, natural gas, and natural gas liquids reserves: 1988 Annual Report, October.

3 Derived from Exxon information.

4 DeBruin, R.H., and Jones, R.W., 1989, Coalbed methane in Wyoming: Wyoming Geological Association 40th Annual Field Conference Guidebook, Casper, Wyoming, p. 97-103.

5 Law, B.E., and others, 1989, Estimates of gas resources in overpressured low-permeability Cretaceous and Tertiary sandstone reservoirs, Greater Green River Basin, Wyoming, Colorado, and Utah: Wyoming Geological Association, 40th Annual Field Conference Guidebook, Casper, Wyoming p. 39-61.

6 Wood, G.H., Jr. and Bour W.V., III, 1988, Coal map of North America: U.S. Geological Survey Special Geologic Map, 1:500,000 scale (color) and 44 p. pamphlet.

7 Geological Survey of Wyoming, April, 1989. (Modified from Berryhill, H.L., Jr. and others, 1950), Coal resources of Wyoming: U.S. Geological Survey Circular 81, 78 p.

8 Culbertson, W.C., 1983, Genesis and distribution of trona deposits in Wyoming (abstract) in Genesis and exploration of metallic and nonmetallic mineral and ore deposits of Wyoming and adjacent areas: Geological Survey of Wyoming Public Information Circular 19, p.34.

9 Energy Information Administration, 1985, Uranium industry annual: U.S. Department of Energy Report DOE/EIA-0478(85) 142 p.

10 Knutson, C.F., and Dana, G.F., 1982, Developments in oil shale in 1981: American Association of Petroleum Geologists Bulletin, Volume 66, no. 11, p. 2513.

M. Ampolex Inc. discovered WD Field with their 34-34 Wolff well in section 34, T.49N., R.71W. The Minnelusa producer was completed for 359 barrels of oil per day. The company's 21-3C-T well in section 3, T.48N., R.71W. offsets the discovery and is currently producing 320 barrels of oil daily.

N. West Prong Field has its third and fourth Minnelusa producer. Quintana Petroleum completed the 1-35 Wood well in section 35, T.51N., R.68W. for an initial pumping potential of 617 barrels of 20° API gravity oil per day. Quintana completed the 3-35 West Prong-Federal, also in section 35, pumping 450 barrels of oil daily.

O. The 13-34 Lois-Federal well, in section 34, T.51N., R.70W., drilled by Pacific Enterprises Oil discovered oil in the Minnelusa. The well pumped 505 barrels of oil per day. Pacific Enterprises has staked three additional Minnelusa tests in the area.

Reference Cited

DeBruin, R.H., and Jones, R.W., 1989, Coalbed methane in Wyoming: Wyoming Geological Association, 40th Annual Field Conference Guidebook, Casper, Wyoming, p. 97-103.

COAL UPDATE

by Richard W. Jones, Coal Division Head, Geological Survey of Wyoming

Coal production in Wyoming for 1989 is apparently heading for another all-time record high. Reported coal deliveries from the State's mines for the first 5 months of the year are about 6.5 million tons ahead of deliveries for the same period in 1988 (see Table 5 and Figure 4). If coal deliveries during the last 7 months of 1988 only equal those made during the same period in 1988, Wyoming's coal production should reach 170 million tons.

Much of the increase in coal deliveries this year is due to a surge in coal sold on the spot market. Almost twice as much spot coal was delivered during the first 5 months of 1989 as was delivered during the same period in 1988. Nearly 5 million tons of spot coal was delivered during the first 5 months of this year; this amounted to about 7.5 percent of the total deliveries. The increase in coal deliveries in 1989 is occurring primarily in existing rather than new coal markets; major increases in deliveries were noted in Texas, Oklahoma, and Indiana while decreased deliveries occurred only in Illinois, Nevada, and Oregon.

Because of these observed increases in coal deliveries as well as the increased activity in coal contracts (summarized later in this report), our production forecast from the second quarter has been revised upward to reflect this (see Table 6 and

Table 5. COAL DELIVERIES BY MONTH FROM WYOMING MINES[1]

	1985 MONTHLY	1985 CUMULATIVE	1986 MONTHLY	1986 CUMULATIVE	1987 MONTHLY	1987 CUMULATIVE	1988 MONTHLY	1988 CUMULATIVE	1989 MONTHLY	1989 CUMULATIVE
JANUARY	11,601,200	11,601,200	11,646,300	11,646,300	12,085,570	12,085,570	10,976,860	10,976,860	14,283,020	14,283,020
FEBRUARY	10,473,900	22,075,100	10,317,700	21,964,000	10,315,680	22,401,250	11,431,380	22,408,240	11,488,140	25,771,160
MARCH	11,674,900	33,750,000	11,401,720	33,365,720	10,436,610	32,837,860	12,871,090	35,279,330	14,124,330	39,895,490
APRIL	11,632,800	45,382,800	9,954,170	43,319,890	10,429,180	43,267,040	12,694,660	47,973,990	13,489,450	53,384,940
MAY	11,497,900	56,880,700	10,105,320	53,425,210	10,619,470	53,886,510	12,017,500	59,991,490	13,149,170	66,534,110
JUNE	11,692,200	68,572,900	10,499,280	63,924,490	11,953,650	65,840,160	12,595,480	72,586,970		
JULY	11,893,500	80,466,400	11,497,190	75,421,680	12,850,240	78,690,400	13,905,670	86,492,640		
AUGUST	12,107,100	92,573,500	11,773,510	87,195,190	13,460,470	92,150,870	15,041,090	101,533,730		
SEPTEMBER	11,325,000	103,898,500	11,474,820	98,670,010	12,651,550	104,802,420	13,433,610	114,967,340		
OCTOBER	11,048,500	114,947,000	10,854,670	109,524,680	12,248,080	117,050,500	13,696,190	128,663,530		
NOVEMBER	10,589,700	125,536,700	11,971,990	121,496,670	12,340,720	129,391,220	13,889,890	142,553,420		
DECEMBER	11,459,300	136,996,000	13,025,490	134,522,160	13,008,300	142,399,520	14,540,510	157,093,930		
TOTAL TONNAGE REPORTED	136,996,000		134,522,160		142,399,520		157,093,930			
TOTAL TONNAGE NOT REPORTED	3,784,154		1,782,896		4,089,128		6,494,270			
TOTAL TONNAGE PRODUCED[2]	140,780,154		136,305,056		146,488,648		163,588,200			

[1] Source: National Marketing Reports by Coal Marketronix and COALDAT Marketing Report by DRI, Inc., compiled from FERC Form 423 filed monthly by electric utilities.

[2] Source: Wyoming State Mine Inspector's Annual Reports.

Figure 4. REPORTED DELIVERIES FORM WYOMING COAL MINES.

Figure 5). Most of the future coal production increases will occur in the Powder River Basin and Campbell County in particular. The large, efficient surface mines in the eastern Powder River Basin are capable of producing large amounts of low-sulfur compliance coal (i.e. coal that can meet the standards set by the Clean Air Act for sulfur dioxide emissions). In addition, Powder River Basin coal is available to electric utility companies at relatively low prices. The demand for coal from southern Wyoming should remain about the same. By 1995, Wyoming could be producing almost 200 million tons of coal annually.

Many coal market analysts that have examined various "acid rain" control measures proposed as bills to Congress (including the legislation proposed by President Bush) agree that if individual coal-fired generating plants are allowed to proceed with emission reduction in the best, most efficient, and most economical manner, many of the plants will choose to burn low-sulfur coal. Much of the remaining low-sulfur coal occurs in the western United States and the analysts estimate that from 10 to 60 million tons of additional coal from this area could be required. A large percentage of this additional coal will certainly come from the eastern Powder River Basin. If the final "acid rain" legislation favors the use of low-sulfur western coal, our coal production forecasts for the early- to mid-1990s may be conservative.

Table 6. COAL PRODUCTION AND FORECAST TO 1995 (MILLIONS OF TONS).

	1983[1]	1984[1]	1985[1]	1986[1]	1987[1]	1988[1]	1989	1990	1991	1992	1993	1994	1995
Campbell County	88.2	106.8	113.9	111.0	122.3	135.7	143.7	150.9	156.9	161.6	164.8	168.1	171.5
Converse County	2.7	3.3	3.6	4.8	5.1	5.7	5.9	6.0	6.5	7.0	7.5	7.5	7.5
Sheridan County	2.9	2.5	2.4	1.4	1.2	0.9	0.1	M	M	M	M	M	M
Carbon County	4.8	5.1	3.3	1.5	2.2	4.1	3.5	3.0	2.5	2.0	2.0	2.0	2.0
Sweetwater County	9.5	8.9	13.2	12.9	11.8	12.2	11.8	12.0	12.5	13.0	13.0	13.0	13.0
Lincoln County	4.0	4.1	4.3	4.0	3.8	4.9	5.0	5.2	5.4	5.6	5.8	5.8	5.8
Hot Springs County	M	M	M	M	M	M	M	M	M	M	M	M	M
Total Wyoming[3]	112.2	130.7	140.7	135.7	146.5	163.6	170.0	177.1	183.8	189.2	193.1	196.4	199.8
Annual change	4%	16.5%	7.7%	-3.6%	8.0%	11.7%	3.9%	4.2%	3.8%	2.9%	2.1%	1.7%	1.7%
Estimated contracted production	122.6	137.7	145.2	149.2	150.0	154.9	160.0	165.0	170.0	175.0	180.0	185.0	190.0

[1] These are actual values for comparison. [2] M means minor tonnage (less than 0.1 million tons). Forecast by Geological Survey of Wyoming, October, 1989. [3] Totals may not equal sum of components because of independent rounding.

Figure 5. WYOMING COAL PRODUCTION AND FORECAST TO 1995.

Additional data on Wyoming's 1988 coal production became available in the third quarter of 1989 (see Table 7 and Figure 6). Coal produced from State of Wyoming leases in 1988 declined to almost half of that produced in 1987. The 3.5 million tons produced on State leases generated royalties of about $4.6 million, a decrease of $1.6 million (or 26 percent) from 1987. The average value of this coal increased from $7.31 per ton in 1987 to $10.36 per ton in 1988 because a large percentage of the coal produced in 1988 was higher priced coal from Sweetwater County. About 145.9 million tons of coal were produced on Federal coal leases in Wyoming in calendar year 1988, an increase of 21 percent from 1987. The U.S. Department of the Interior's Minerals Management Service reported that this coal had a total market value of $1.4 billion (average value of $9.62 per ton) and generated royalties of about $91.9 million. The State of Wyoming receives half the Federal royalties collected on the coal.

Another report on Federal coal (U.S. Department of the Interior, 1989) was released in the third quarter of 1989. This report discussed coal produced on a fiscal

Table 7. Coal production statistics for Wyoming.

ARRANGED BY COAL OWNERSHIP

Calendar Year	FEDERAL[1] Short tons	FEDERAL[1] Percent	STATE[2] Short tons	STATE[2] Percent	PRIVATE[3] Short tons	PRIVATE[3] Percent	TOTAL[4] Short tons
1979	30,121,000	42%	10,805,182	15%	30,689,649	43%	71,615,831
1980	33,434,000	35%	21,592,172	23%	39,768,435	42%	94,794,607
1981	59,576,163	58%	26,485,275	26%	16,722,026	16%	102,783,464
1982	63,612,335	59%	19,872,591	18%	24,469,657	23%	107,954,583
1083	67,975,848	61%	18,189,147	16%	26,022,908	23%	112,187,903
1984	69,610,380	53%	19,166,425	15%	42,035,878	32%	130,812,683
1985	100,621,788	72%	16,541,094	12%	23,531,104	17%	140,693,986
1986	111,407,678	82%	8,535,191	6%	16,362,187	12%	136,305,056
1987	120,404,308	82%	6,850,053	5%	19,234,287	13%	146,488,648
1988	145,925,209	89%	3,530,651	2%	14,132,340	9%	163,588,200

COAL PRODUCTION ON STATE LEASES BY COUNTY[2]

Calendar Year	Campbell	Carbon	Converse	Lincoln	Sheridan	Sweetwater	Total
1978	2,103,806	203,818	0	24,917	10,454	0	2,342,995
1979	10,292,768	376,112	0	136,302	0	0	10,805,182
1980	21,417,481	160,584	0	14,107	0	0	21,592,172
1981	26,274,778	186,430	17,953	6,114	0	0	26,485,275
1982	19,015,683	384,578	472,330	0	0	0	19,872,591
1983	17,297,232	353,974	537,941	0	0	0	18,189,147
1984	17,968,567	121,175	889,710	0	0	186,973	19,166,425
1985	15,816,484	79,518	408,906	0	0	236,186	16,541,094
1986	8,340,540	0	0	0	0	194,651	8,535,191
1987	6,850,053	0	0	0	0	0	6,850,053
1988	2,532,519	0	0	0	0	998,132	3,530,651

Data sources:

[1] Minerals Management Service Annual Reports, 1981-1988 and U.S. Dept. of Interior Federal Coal Management Reports, FY 1980 and 1981.
[2] Wyoming Department of Public Lands Annual Reports, 1979-1989.
[3] Derived by subtraction of State and Federal production from total.
[4] Annual Reports, Wyoming State Mine Inspector and Wyoming Ad Valorem Tax Division.

Figure 6. WYOMING COAL PRODUCTION BY OWNERSHIP CATEGORY.

year basis rather than a calendar year basis as above. It was reported that Wyoming coal mines accounted for 71 percent (or 133.4 million tons) of the total 187 million tons of Federal coal produced in fiscal year 1988. Montana and Utah accounted for 11 percent and 8.2 percent, respectively, of the Federal coal produced. Production of Federal coal in Fiscal Year 1988 accounted for 19.5 percent of the total coal production in the U.S.

In coal transportation news, the 8th U.S. Circuit Court of Appeals recently overturned an April, 1988, jury verdict that awarded $600 million to the State of South Dakota in connection with a cancelled water contract for the Energy Transportation Systems, Incorporated (ETSI) coal slurry pipeline project. Although most of the other lawsuits filed by ETSI against western railroad companies have been settled out of court (see *Wyoming Geo-notes No. 22*, April, 1989, p. 17), an appeal still pending in the 5th Circuit Court of Appeals with Santa Fe Southern Pacific Corporation (SFSP) could be influenced by this latest reversal. To date, ETSI has received about $250 million in settlements from five railroads involved in the lawsuits.

In July, Burlington Northern Railroad (BN) signed a new long-term coal transportation contract with American Electric Power (AEP). The 10-million-ton per year contract replaces an existing coal transportation contract that was due to expire in 2.5 years. It also adds new coal tonnage recently contracted by AEP for Indiana-Michigan Power Company's Rockport Unit 2 (see story below in **Coal contracts -**

Powder River Basin). The new contract covers coal shipments from Carter Mining Company's Rawhide and Caballo mines to Rockport Unit 1 in Indiana as well as new shipments from the Rochelle mine to Rockport Unit 2, which will begin in 1990.

Developments in western and southwestern Wyoming

In July, Arch Mineral Corporation purchased Bitter Creek Resources' recently-opened Stansbury underground mine. As part of the purchase agreement, Arch Mineral paid off a $950,000 loan that the State of Wyoming had given Bitter Creek Resources to help start the mine. Evidently a 15,000-ton per month contract that the mine had to supply coal to Pacific Power and Light's (PP&L) Jim Bridger plant will continue, even though no shipments have been made to the plant since early in 1989. Arch Mineral Corporation and its subsidiary Arch of Wyoming, which operates the Seminoe 2 and Medicine Bow surface mines in the Hanna Basin, are conducting engineering studies at their new underground mine to determine how to expand production and increase efficiency at the mine. Arch is also attempting to find additional customers for the high quality bituminous coal.

Another development that might affect southern Wyoming coal markets is the possibility that the Los Angeles Department of Water and Power (L.A.) might conduct a test burn of Wyoming coal at its Intermountain Power Project (IPP) in Utah. When IPP was constructed, L.A. agreed to use only Utah coal in the generating units. If there is not enough Utah coal available at an agreeable price, L.A. may turn to Wyoming to expand its coal supply base for the project.

Developments in the Hanna Coal Field

Development activity in the Hanna Basin was relatively quiet during third quarter 1989. Cyprus Coal Company, owner of the Shoshone No. 1 underground mine north of Hanna, has been repairing, rebuilding, and improving its longwall operation in this mine with the intent of doubling the mine's capacity. The mine is currently capable of producing about 1.5 million tons per year. The mine has a 14-year, 1.3-million-ton per year contract and sells about 0.2 million ton per year as spot sales.

Arch of Wyoming is supplying an unspecified amount of coal to Holly Sugar Company's Torrington, Wyoming sugar beet plant. This plant uses about 20,000 tons of coal per year on a seasonal basis. The specific Hanna Basin coal mine that will supply the coal is not known, but it is probably the Medicine Bow mine.

Developments in the Powder River Basin Coal Field

Coal production at Wyodak Resources Development Corporation's Wyodak mine east of Gillette was slowed this summer because of a shutdown at Pacific Power & Light Company's nearby Wyodak generating plant. A turbine problem discovered at the plant during routine maintenance caused the shutdown and halted coal deliveries from Wyodak. Coal production at Wyodak was expected to decrease by 330,000 tons this year as monthly production dropped from 197,000 tons to

72,000 tons. Coal shipments to Wyodak's other customers continued and no layoffs of personnel were made. The Wyodak plant was expected to be back in operation in August, 1989.

Powder River Basin coal appeared to be making inroads into the eastern United States as coal deliveries from Wyoming have been made to New Hampshire, New York, and Georgia so far this year. Spot coal for use in test burns has been shipped from Wyoming, Colorado, and Montana to Public Service New Hampshire's Merrimac generating plant.

In February of 1989 Rochelle Coal shipped a small delivery to the Carlson, New York generating plant (operated by Jamestown Board of Public Utilities).

In August, Nerco Coal Corporation's Antelope mine sold 80,000 to 90,000 tons of spot coal to Georgia Power Company (GPC). This sale has been called "the farthest eastern penetration of western coal into the eastern markets not officially called a test burn" (McGraw-Hill, Inc., 1989). The coal was shipped 1,900 miles by BN to GPC's Yates and Wansley power plants near Atlanta, Georgia. The Wyoming coal was blended with 90 percent Illinois coal at a transloader location along the Mississippi River in Alabama and then was shipped by rail to the power plants.

Coal contracts - Powder River Basin

Two long-term contracts for Wyoming coal were announced in the third quarter, 1989. Peabody Coal Company of Wyoming signed a 15-year, 0.8 million ton per year coal supply contract with Empire District Electric Company (EDECO) and a 15-year, 3-million-ton per year coal supply contract with American Electric Power Service Company (AEP) (also see *Wyoming Geo-notes No. 23*, page 20). The contract with EDECO calls for Rochelle Coal Company's Rochelle mine (located in southern Campbell County) to supply coal to EDECO's Asbury and Riverton plants in southeastern Kansas beginning in April, 1990. The coal will originate on Chicago and North Western Railroad (C&NW) at Rochelle and then be delivered via Union Pacific (UP) and Kansas City Southern (KCS) rail lines. The new contract with Rochelle replaces EDECO's expiring 19-year contract with a Pittsburg and Midway Coal Mining Company mine in Kansas.

The new AEP contract calls for minimum deliveries of 3 million tons of coal per year from the Rochelle mine to AEP's Rockport 2 plant (operated by Indiana-Michigan Power Company). The coal will be delivered to the Rockport, Indiana plant via Burlington Northern Railroad (BN) to Metropolis, Illinois where it will be transloaded on barges and shipped the remaining distance on the Ohio River. Carter Mining Company currently supplies 4.75 million tons of coal per year to the Rockport Unit 1 and evidently AEP is negotiating the purchase of an additional 2 million tons per year from other coal suppliers in the Powder River Basin, Wyoming.

Activity in spot and short-term coal supply contracts was brisk in the third quarter of 1989. The activity is summarized below:

1) Cordero Mining Company, a subsidiary of Sun Coal Company, has most likely won a contract for 239,400 tons of spot coal for the Lower Colorado River Authority's (LCRA) Fayette Units 1 and 2 in Texas. Published bids for the coal ranged from the low of $3.50 per ton F.O.B. mine submitted by Cordero for 8,375 Btu/pound coal to a high of $4.95 per ton for 8,775 Btu/pound coal.

2) Amax Coal Company supplied Northern Indiana Public Service Company (NIPSCO) with 100,000 tons of coal for July as the utility continued to purchase spot coal on a monthly basis. This spot sale will be supplied from the Belle Ayr mine to various Indiana power plants.

3) Carter Mining Company's Rawhide mine, Mobil Coal Producing, Incorporated's Caballo Rojo mine, and Triton Coal Company's Buckskin mine have delivered a total of about 0.5 million tons of spot coal to Grand River Dam Authority (GRDA), Oklahoma so far this year. GRDA has increased its coal usage this year as demand for electricity and off-system power sales increase.

4) Amax Coal Company and Exxon Coal and Minerals (of which Carter Mining Company is a subsidiary) both signed contracts for 325,000 tons of spot coal each for Houston Lighting and Power Company's Parrish, Texas generating plant. Coal from the Belle Ayr and Caballo mines will be delivered through December, 1989 via Burlington Northern and Santa Fe Railroads.

5) Cordero Mining Company is supplying up to 1.0 million tons of spot coal from its Cordero mine to Iowa-Illinois Gas and Electric Company's Louisa, Iowa plant. Deliveries of this coal began in July and will continue until the end of the year. Cordero supplies the same utility with contract coal under a 20-year agreement. Burlington Northern and Soo Line railroads will deliver the coal.

6) Kerr-McGee Coal Corporation's Jacobs Ranch mine will supply 50,000 tons of spot coal (with possibly an option for an additional 25,000 tons) to the Fremont, Nebraska Department of Utilities. Deliveries began in late June and will continue through late 1989. The coal was priced at $4.00 a ton F.O.B. Jacobs Ranch mine and $14.95 a ton delivered via Burlington Northern. Although Carter Mining Company submitted a lower bid of 86.7 cents per million Btu's delivered, as compared to 86.9 cents per million Btu's delivered from Jacobs Ranch, Kerr-McGee reportedly offered quality guarantees that made their coal more attractive to the utility. Six of the bids on this contract solicitation were all below 90 cents per million Btu's delivered.

7) Rochelle Coal Company signed a spot coal contract with Dairyland Electric Power Cooperative to supply 140,000 tons of coal to the Alma and Genoa, Wisconsin power plants. The coal deliveries, which started in July, will run through the fall of 1989 via Burlington Northern and river barges at St. Paul, Minnesota.

8) Amax Coal Company's Belle Ayr mine will supply 250,000 tons of coal to Omaha Public Power District's Nebraska City plant and possibly to the North Omaha,

Nebraska generating plant. Deliveries on Burlington Northern began in August and could continue into November, 1989.

9) Thunder Basin Coal Company (a subsidiary of Arco Coal Company) and Nerco Coal Corporation will supply a total of 300,000 to 450,000 tons of coal to Consumers Power Company's Cobb, Michigan generating plant. Coal deliveries from the Black Thunder and Antelope coal mines began in the second quarter of 1989.

References cited

McGraw-Hill, Inc., 1989, Southern faces west for spot; PRB coal goes to Georgia Power: Coal Week, v. 15, no. 35 (August 28, 1989), p. 1.

U.S. Department of the Interior, 1989, Federal coal management report, Fiscal Year 1988, 70 p.

INDUSTRIAL MINERALS AND URANIUM UPDATE

by Ray E. Harris, Industrial Minerals and Uranium Division Head, Geological Survey of Wyoming

Abrasives

Natural abrasives are minerals used for grinding, honing, lapping, superfinishing, polishing, pressure blasting, or barrel finishing (Thrush, 1968). Natural minerals used in abrasives include diamond, corundum, garnet, and quartz. Due to recent health concerns about silica dust, natural quartz has become less popular for all types of abrasives. Garnet has become a more popular low-hardness abrasive, particularly for use in sandblasting and other pressure-blasting applications.

Nationally, most garnet is produced by three companies from large deposits in the Adirondack Mountains of New York, with smaller production from Maine and Idaho. Production of garnet in New York is becoming more expensive due to depletion of the deposits and high costs related to operating in an environmentally sensitive area.

Perhaps for this reason, the Geological Survey of Wyoming has recently received several inquiries about garnet in Wyoming. In Wyoming, garnet is found in certain schists. The largest known occurrences occur in the Haystack Hills of east-central Wyoming and in the Teton Mountains, outside of Grand Teton National Park. Garnets are also found in the Laramie Mountains, Medicine Bow Mountains, Sierra Madre, and Wind River Range. Placer garnets occur in the Black Hills. If any readers know of or have a garnet deposit, please contact the Geological Survey of Wyoming. There are some companies interested in finding and developing minable garnet in Wyoming.

Bentonite

Bentonite is a clay product that has many uses. It swells many times its dry volume when wet and has a high cation exchange capacity. These properties make it useful as a sealant, as in oil well drilling fluid, in lining settling ponds, and in certain construction applications. It is also used in iron ore refining, foundry casting, soap, cosmetics,and as a mineral filler in many products.

Bentonite is Wyoming's second most important industrial mineral (after mined trona) in the value of its production. The major producing areas are the Colony area in the northern Black Hills, the Clay Spur area in the southern Black Hills, the eastern Bighorn Basin, the Kaycee area, and near Casper (see Figure 7).

Since the main use of bentonite is for drilling muds, the decline in domestic oil and gas exploration has depressed the bentonite industry. However, because other uses of bentonite are increasing, bentonite production in Wyoming is increasing slowly (Table 2 on page 3). Bentonite gravels are now being used by seismic operators to prevent blow-outs and to simplify the plugging of shot holes. In addition, newly developed bentonite grouts are making inroads in many downhole applications, including water well completion techniques. Wyoming is still the Nation's largest producer of bentonite.

Cement

Cement is a manufactured product produced by heating high-calcium limestone, shale, and gypsum together. Different grades of cement are made using different proportions of the primary ingredients, or by introducing different additives. There is one cement plant in Wyoming, the Mountain Cement Company's newly remodeled plant south of Laramie. This plant uses limestone from the Permian-Pennsylvanian Casper Formation, quarried just east of the plant; marl from the Cretaceous Niobrara Formation, quarried just west of the plant; and gypsum from the Triassic Chugwater Formation, quarried 40 road miles southwest of the plant. Small amounts of titaniferous magnetite from stockpiles at the old Iron Mountain mine, 50 miles northeast of Laramie, are used as additives.

Production from Mountain Cement's plant is running near capacity. Due to the plant's recent renovation and the high quality marl that is used in the process, this plant is highly competitive in the regional cement market. The plant employs about 100 people in the Laramie area .

Gypsum

Gypsum is produced by three companies in Wyoming. It is produced for the Mountain Cement plant in Laramie (see **Cement**). In addition, the Celotex Corporation in Cody and the Georgia-Pacific Company in Greybull mine gypsum and manufacture wallboard. The daily production of gypsum in Wyoming is expected to remain steady for the rest of the year.

Figure 7. SELECTED MINERAL AND ROCK OCCURRENCES.

According to figures recently released by the U.S. Bureau of Mines, gypsum is produced by 34 companies operating 64 mines in 21 states. The leading states in the production of finished gypsum products are California, Texas, Florida, Iowa, and Nevada. Although Wyoming may be a relatively minor contributor to the Nation's total production of gypsum, wallboard from Wyoming is in demand in Wyoming, Montana, and the Pacific Northwest.

Limestone

Limestone is quarried in Wyoming for cement (see **Cement**), construction aggregate (particularly highway base, sub-base, and surfacing), and for use in emissions control at coal-fired power plants. Wyoming has been exporting crushed limestone from near Hartville to the State of Nebraska for use as aggregate for road construction. In the past, limestone has been produced in Wyoming as dimension stone and as "sugar rock" for use in refining sugar beets.

Limestone production in Wyoming is heavily dependent on road construction. Overall, the long-term production of limestone is expected to increase, especially if markets are established in adjacent states. Limestone production will decrease this winter with the seasonal slowdown in construction.

Mica

Mica is a mineral that can occur in large crystals called "books". Thin, transparent, individual sheets may be split from these "books". In the years before World War II, these sheets were used in heat-resistant windows. Historically, there has been no interest in mica from Wyoming. Recently, however, there have been a few inquiries regarding mica availability for export to the Orient for use in roofing and construction.

Large mica "books" are known to occur in Wyoming primarily in the Tie Siding and Medicine Bow Mountains areas in Albany County, in the Laramie Mountains in Albany, Converse, Laramie, and Platte Counties, and in the Haystack Hills in Goshen County. Today, a large deposit of transparent, sheet mica is of economic interest.

Phosphate, sulfur, and fertilizer raw materials

At Coastal Corporation's (formerly WYCON's) fertilizer plant west of Cheyenne, fertilizer is produced from urea and ammonia compounds. This plant does not use mineral products in its process. At Chevron's fertilizer plant near Rock Springs, however, phosphate mined in Utah is combined with sulfur produced as a by-product of natural gas refining in Wyoming.

Chevron's fertilizer plant near Rock Springs is operating at a production rate about five percent over its rated capacity, according to company officials. This means that the plant will produce about 450,000 tons of fertilizer in 1989. Regional demand remains high despite a national decrease in the demand for fertilizer.

Silica raw materials

Two high-silica sand or rock deposits have recently been investigated by the Geological Survey of Wyoming (Harris, 1988a and 1988b). A third deposit in the Lovell area is now under investigation by the Geological Survey of Wyoming. The study has been funded through the Wyoming Economic Development and Stabilization Board. The reason for all of these studies is the great interest in the possible production of glass in Wyoming. This recent interest is due to several factors: more favorable transportation rates, new ways of manufacturing and transporting glass, and promising research into heat resistant ceramics, which may be substituted for metal in products such as automobile engines.

Wyoming contains within its borders all of the major raw materials used to make glass including silica, soda ash (refined trona), feldspar, limestone, pigments, and others. Several companies are currently investigating the development of a glass plant in Wyoming. It appears now that a glass and ceramic manufacturing industry may be a real possibility in Wyoming's future.

Stone

Dimension stone has been produced in Wyoming in past years for local and regional construction. Until the mid-1950's, the Jay Em Stone Company in Jay Em, Wyoming produced monument stone and finished monuments from Wyoming stone. The major suppliers of dimension stone are currently Italy and other foreign sources, Indiana limestone, Georgia marble and granite, Vermont marble and granite, and a few quarries in other states including Tennessee, Alabama, Missouri, and Colorado.

With improving transportation rates, as well as increasingly restrictive environmental regulations in populous areas, it is becoming more advantageous for a dimension stone producer to locate in the West. Although no producer has decided to locate in Wyoming, several have visited and looked at various stone types and occurrences. Wyoming has an incredible variety of stone, particularly granite of all types and colors, as well as quartzite, sandstone, and a little marble. Stone offers another potential industry for Wyoming.

Trona

The production of soda ash (refined trona) and other sodium chemical products in Wyoming continues at record levels (see *Wyoming Geo-notes no. 23,* p. 23). As expected, the soda ash producers, which are now operating near capacity, have seen an increasing market. Two plants announced expansion plans during the last quarter.

Tenneco Minerals Co., and Tg SodaAsh both plan plant expansions. Tenneco's expansion will create 10 new jobs and result in the production of about 125,000 more tons of soda ash per year. Tg SodaAsh's plans, which call for increasing capacity

by 100,000 tons per year, will create only one or two additional jobs. The current growth in production at the soda ash plants is the result of increased efficiency rather than increases in manpower.

The soda ash producers see continued increases in the demand for their sodium products. In addition to the production of soda ash, there have been increases in the demand for caustic soda and sodium cyanide. Sodium cyanide is being used to extract gold from Nevada, Washington, and Montana ores.

Exports continue to hold promise as a way of increasing demand for Wyoming soda ash. Most soda ash produced in the Orient is manufactured by the Solvay process, which is more expensive than refining mined trona. Import tariffs have kept the price of American soda ash high in Japan, Korea, China, and Taiwan. During the past quarter, however, Taiwan has cut its tariff on soda ash. If other Pacific Rim countries follow suit, there will be a greatly increased demand for American soda ash. Wyoming produces over 90% of all American soda ash.

On a related theme, the recent unrest in the People's Republic of China has not affected export sales of U.S. soda ash. China buys more soda ash from the U.S. than any other foreign country. China's purchases of soda ash now require a letter of credit, however, rather than being continued on a draft basis. Exports to China are expected to decrease in the future as China develops its own soda ash production. Increased exports to other countries should take up the slack resulting from China's decreased requirements.

Uranium

Uranium is still produced at three localities in Wyoming. Pathfinder Mines mines uranium ore by open-pit methods and mills the ore into yellowcake (uranium oxide, U_3O_8) at Shirley Basin. Everest Minerals and Malapai Resources mine uranium by *in situ*, solution mining methods and produce yellowcake at the Highland property and the Irigary-Christensen Ranch property, respectively. Both of these operations are in the Powder River Basin. U.S. Energy has produced yellowcake from the Crook's Gap area. Presently, low uranium prices have suspended this project.

The uranium spot market price of $9.80 per pound of yellowcake is at a new low. Uranium industry officials see this low spot market price continuing, according to an article in the *Casper Star-Tribune*. Low prices resulting from an oversupply of yellowcake should continue to plague the industry through the early 1990's.

Other uranium-producing states are feeling the effect of this depressed market. Chevron Uranium announced in September that it is going to close its Mount Taylor uranium mine in west-central New Mexico. This mine was one of New Mexico's largest, and its closing may affect other mines in the Grants area. Because Chevron's ore is milled by Homestake, there may not be enough ore for the mill to operate at a profit; thereby, requiring the closure of the mill and the other mines in the area.

In July, the U.S. Senate approved a bill designed to help the Government's uranium-enrichment programs. This legislation would enable the U.S. to continue to enrich uranium from about 0.07% U-235 to the 3.0% U-235 that is used to produce heat for the generation of electricity.

References cited

Harris, R.E., 1988a, The Plumbago Creek silica sand deposit, Albany County, Wyoming: Geological Survey of Wyoming Report of Investigations 40, 32p.

Harris, R.E., 1988b, The Cassa silica rock deposit, Platte County, Wyoming: Geological Survey of Wyoming Report of Investigations 42, 38p.

Thrush, P. W., 1968, A dictionary of mining, mineral, and related terms: U. S. Bureau of Mines, Pittsburgh, Pennsylvania, 1,269 p.

METALS AND PRECIOUS STONES UPDATE

by W. Dan Hausel, Deputy Director, Geological Survey of Wyoming

In the summer and fall of 1989, companies and individuals continued to explore Wyoming for gold, platinum, and palladium. Drill rigs were testing precious metals targets in the South Pass and Medicine Bow Mountains areas at the end of this quarter. Exploration for precious metals also continued in the Bighorn Basin, Bear Lodge Mountains, Mineral Hill district, and in the Silver Crown district. One Australian firm, Carr Boyd Minerals, Ltd., conducted an airborne multi-spectral scanner survey of Wyoming's Archean terrain. According to the *Engineering and Mining Journal* (July, 1989, p. 72), the company's multi-spectral scanner is capable of delineating a diverse range of mineral deposits. The scanner has been used successfully in Western Australia to identify auriferous (gold-bearing)shear zones and diamondiferous lamproites.

During the third quarter, inquiries about Wyoming's base metal (copper, lead, and zinc) resources, continued to increase. This interest is stimulated by the current high prices for base metals, and by the State's relatively untapped wealth in these metal deposits.

In addition to company interest, the Metals and Precious Stones Division of the Geological Survey of Wyoming initiated a research project to study the mineral deposits in the Seminoe Mountains district of central Wyoming and continued its investigations for diamond deposits in the Laramie Range.

As a note of interest, the Geological Survey of Wyoming is scheduled to receive about 12 tons of drill core from the U.S. Bureau of Mines in October. This core is from the Bureau's drilling projects on strategic mineral deposits in Wyoming back in the

1940s. Some of the drill core is from the New Rambler and Copper King deposits, both of which are currently being explored for precious metals.

Black Hills uplift

Gold exploration is reported in two regions of the Black Hills. In the Bear Lodge Mountains north of Sundance, mining companies continued to search for large-tonnage, low-grade gold mineralization in feldspathic trachyte breccias. In the Mineral Hill district to the east, TRYCCO, Inc. continued testing placers for gold, tantalite, and cassiterite.

Bighorn Basin

The *Casper Star-Tribune* (August 22, 1989) reported that American Mining and Milling (AM&M) from Gillette, Wyoming, has applied for a permit to mine gold and silver from stream gravels in the Clarks Fork River in Park County. American's application to the State Department of Environmental Quality includes a security patrol at the mine site. The known gold deposits in this region occur in small placers (Hausel, 1989, p. 34).

In the same general region, American Mining and Milling, has also expressed interest in recovering gold from the Sand Coulee placer north of Cody. The Sand Coulee is a relatively small drainage containing abundant garnet and common gold flakes from an unknown source.

Laramie Range

The Geological Survey of Wyoming continued its search for diamond deposits in the central Laramie Range. Several significant heavy mineral anomalies discovered by the State Survey (Hausel and others, 1988), are being examined in greater detail. With the help of electromagnetic and magnetic surveys, the Survey is investigating the site from which one stream-sediment sample yielded nearly 100 pyrope garnets. These garnets indicate that there may be a kimberlite in the area.

Medicine Bow Mountains

The Geological Survey of Wyoming has begun a study of historic mines in the Medicine Bow Mountains. Samples are being collected for assay, and ore shoots are being investigated for their type and geometry.

Elsewhere, at least three drill rigs were testing precious metal targets during the third quarter of 1989. According to the *Engineering and Mining Journal* (December, 1988, p. 72), Vanderbilt Gold Corporation was investigating two gold-platinum properties in the Mullen Creek and Lake Owens areas. At Mullen Creek, the company's magnetic surveys, geological mapping, and stream-sediment analysis defined at least two targets worth drilling. At Lake Owens, magnetic surveys, soil sample geochemistry, geologic mapping, and outcrop sampling identified three drilling targets.

Seminoe Mountains

The Geological Survey of Wyoming has begun investigating the mines and geology of the Bradley Peak area of the Seminoe Mountains greenstone belt north of Rawlins. Based on an initial reconnaissance study of the area, with one exception the belt is similar to the South Pass greenstone belt in the Wind River Range of western Wyoming. The Seminoe Mountains belt lacks a thick metagreywacke succession, and is dominated by a relatively thick ultramafic unit containing serpentinites and tremolite schists. These ultramafic rocks are similar to high-magnesian rocks found in South Africa and Western Australia, and are interpreted to represent metamorphosed dunite and peridotite sills, and peridotitic and basaltic komatiite flows. Several of the basaltic komatiites in the Seminoe Mountains have relict spinifex textures typical of basaltic komatiites elsewhere in the world (Snyder and others, 1989).

In Western Australia, commercial nickel deposits are found near the base of komatiite flows. Using this model, the Geological Survey of Wyoming is sampling gossans in the Bradley Peak komatiites to test for anomalous nickel concentrations.

The Bradley Peak area also has several historic gold mines and prospects localized in carbonated and chloritized metagabbro and metabasalt (Klein, 1981). These are being mapped in detail to identify ore shoots and potential areas of gold and copper mineralization. Many of the veins are isoclinally folded suggesting the possibility of ore shoots in fold closures, and the State Survey has also recognized stockworks suggesting the possibility of unrecognized large-tonnage, low-grade gold deposits.

Banded iron formation in this region also shows zones of carbonation and pyritization. The banded iron formation is also being investigated as a potential iron resource as well as a potential host for epigenetic gold deposits.

Structurally, Bradley Peak is complex. Brittle deformation related to the Laramide orogeny has overprinted many Archean structures, and at least two and possibly three Archean folding events have taken place. The initial event was an isoclinal folding event, which was overprinted by a later open folding event that included some chevron geometries.

South Pass

The State Survey has completed its field investigations of the South Pass greenstone belt and is preparing a final report on the geology and mineral deposits, as well as a small scale (1:48,000) geologic map of the belt compiled from eight, detailed, 1:24,000-scale geologic maps authored by the Survey. Research by the State Survey in the South Pass region indicates that South Pass has high potential for hosting significant commercial gold and iron deposits. The region also has some potential for commercial tungsten, nickel, copper, and silver mineralization. Other interesting metals identified in anomalous amounts include tin and chromium. The

potential for hidden gold deposits is also considered high. A few results from this study were recently published in Hausel (1989), but the final report is still forthcoming.

Many gold deposits in the South Pass greenstone belt are found in ore shoots in shear zones. Finding the local ore shoots in the more extensive shear zones has always been a problem in the greenstone belt, but geochemical data along with detailed geological mapping has shown that ore shoots are localized at intersections of structures, at fold closures, and at slight attitude changes in veins. Although more detailed work is necessary, it now appears that ore shoots are locatable through detailed geological mapping.

Exploration and mining activity this summer in the South Pass greenstone belt included gold recovery from the Stout placer mine on Rock Creek, some claim staking, and drilling by two mining companies at undisclosed locations.

Silver Crown District

Royal Gold, Inc., of Denver reportedly signed an option agreement with Henrietta mines of Vancouver, British Columbia and Kirkwood Exploration of Casper, Wyoming to purchase all of the outstanding shares in the Copper King property located between Laramie and Cheyenne. The Copper King is a mineralized porphyry which contains reported reserves of 3.6 million tons of ore averaging 0.4% copper and 0.04 ounce/ton gold (*Engineering and Mining Journal*, May, 1989, p. 73).

Field trips, seminars, and recent articles

The Metals and Precious Stones Division of the Geological Survey of Wyoming worked with George Snyder and Terry Klein of the U.S. Geological Survey; Robert Houston of the University of Wyoming; and Paul Graff, consultant from Casper, to organize and co-lead an International Geological Congress field trip through the Archean geology and mineral deposits of parts of Wyoming. Field trip participants began on July 19th in the Hartville uplift; traveled through the Elmers Rock greenstone belt of the Laramie Range; examined shear zone structures and related folds in the Medicine Bow Mountains; toured the Seminoe Mountains and South Pass greenstone belts; and finished on July 25th in the Copper Mountain supracrustal belt of the Owl Creek Mountains. The attendees included delegates from China, the Soviet Union, Spain, France, South Africa, Sierra Leone, and the United States. One of the many highlights of the field trip was the recovery of several hand specimens from South Pass that contained visible gold.

On Saturday, September 16th, the Head of the Metals and Precious Stones Division also taught a seminar on methods used to find and identify gold and diamond deposits. The seminar was so well received that additional seminars, including field trips, are being considered for next year.

The Division published one paper and one abstract outside the State Survey during the past quarter:

(1) Hausel, W.D., Erlich, E.I., and Sutherland, W.M., 1989, Timing of alkaline and ultramafic-alkaline volcanism within the Russian, the Siberian, and the North American ancient platforms [abstract] *in* Continental magmatism: New Mexico Bureau of Mines and Mineral Resources Bulletin 131, p. 123.

(2) Snyder, G.L., Hausel, W.D., Klein, K.L, Houston, R.S., and Graff, P.J., 1989, Precambrian rocks and mineralization, Southern Wyoming Province: 28th International Geological Congress Field Trip Guidebook T332, 48 p.

References Cited

Hausel, W.D., 1989, The geology of Wyoming's precious metal lode and placer deposits: Geological Survey of Wyoming Bulletin 68, 248 p.

Hausel,W.D., 1988, Stream-sediment sample results in search of kimberlite intrusives in southeastern Wyoming: Geological Survey of Wyoming Open File Report 88-11, 11 p.

Klein, T.L., 1981, The geology and geochemistry of the sulfide deposits of the Seminoe district, Carbon County, Wyoming: Colorado School of Mines, Ph.D. dissertation, 232 p.

GEOLOGIC MAPPING AND STRATIGRAPHY

by Alan J. VerPloeg, Stratigraphy Division Head, Geological Survey of Wyoming

The Stratigraphy Division of the State Survey recently initiated work on a revised geologic map of the Arminto 1° x 2° Quadrangle, central Wyoming. This new map will be a colored revision of the black and white map titled *Preliminary geologic map of the Arminto 1° x 2° Quadrangle, central Wyoming* released by the U. S. Geological Survey as Open File Report 78-1089 in 1978. Revisions will be based on new 1:24,000-scale mapping by the Stratigraphy Division, recent thesis maps from the University of Wyoming and out-of-state universities, and new U. S. Geological Survey mapping. This project is part of an effort by the Geological Survey of Wyoming to publish a complete set of colored 1° x 2° (1:250,000-scale) quadrangles for the State of Wyoming. To date, the Newcastle Quadrangle has been published in color as MS-25I by the Geological Survey of Wyoming and the Preston Quadrangle by the U. S. Geological Survey as I-1127. The Gillette Quadrangle is currently being drafted and should be published in early 1990.

The Division completed work on two new preliminary 1:24,000-scale geologic maps as part of the southern Bighorn Mountains mapping project. These maps are titled, *Preliminary geologic map of the Tallon Spring Quadrangle, Washakie and Johnson Counties, Wyoming* and *Preliminary geologic map of the Turk Springs Quadrangle, Washakie and Johnson Counties, Wyoming* and are designated Open File Reports 89-5 and 89-6, respectively. These two maps represent the sixth and seventh maps produced by the southern Bighorn Mountains COGEOMAP Project (Figure 8).

The Tallon Spring Quadrangle is especially interesting in that it details a segment of the Big Trails Fault System. This major fault system trends south-southwest to north-northeast, running from the northwest corner of Natrona County, north to the Tensleep Fault and possibly beyond. In fact, there is evidence on aerial photographs that the fault system may run as far north as the canyon of the North Fork of Crazy Woman Creek, south of Buffalo. This fault system appears to have significant right lateral movement along with subordinate vertical movement. Numerous "horse-tail" faults were mapped splaying off of the main fault system due to drag. These kinds of faults are characteristic of strike-slip faults. In addition, visible slickensides indicated nearly horizontal movement. More work is needed on the ground to verify the extent of this fault system and to gather additonal evidence for strike-slip movement on the fault. Mapping the Horse Butte Quadrangle immediately to the south of the Tallon Spring Quadrangle should go a long way toward establishing the motion on the Big Trails Fault System. Both the Tallon Spring and Turk Springs Quadrangles are available through the Publications Division of the Geological Survey of Wyoming. The maps cost $3.50 each over-the-counter.

As noted in *Wyoming Geo-notes No. 23*, the Division recently completed four new index maps. The *Index to selected U. S. Geological Survey Bulletins that contain geologic maps for Wyoming* and the *Index to selected U. S. Geological Survey Professional Papers that contain geologic maps for Wyoming* are designated MS-9G and MS-9H, respectively and are now available for $2.50 each from the Publications Division. The *Index of Geological Survey of Wyoming publications that contain geologic maps, excluding open file reports* and the *Index of Geological Survey of Wyoming open file reports that contain geologic maps* will be designated MS-9L and MS-9M, respectively. These two indices are currently at the printers and will be available in November.

Preliminary geologic map of the Mayoworth Quadrangle, Johnson County, Wyoming - - Open File Report 87-4

Preliminary geologic map of the Red Fork Powder River Quadrangle, Johnson County, Wyoming - - Open File Report 87-5

Preliminary geologic map of the Fraker Mountain Quadrangle, Johnson County, Wyoming - - Open File Report 88-4

Preliminary geologic map of the Barnum Quadrangle, Johnson County, Wyoming - - Open File Report 88-5

Preliminary geologic map of the Tabletop Quadrangle, Johnson County, Wyoming - - Open File Report 88-6

Preliminary geologic map of the Tallon Spring Quadrangle, Washakie and Johnson Counties, Wyoming - - Open File Report 89-5

Preliminary geologic map of the Turk Springs Quadrangle, Washakie and Johnson Counties, Wyoming -- Open File Report 89-6

Figure 8. INDEX MAP TO STATE SURVEY MAPPING IN THE SOUTHERN BIGHORN MOUNTAINS

SELENIUM AND LANDSLIDES

by James C. Case, Geologic Hazards Division Head, Geological Survey of Wyoming

In 1988, the Geologic Hazards Division of the State Survey revised an earlier (1985) map and text representing the State's knowledge on the occurrence and distribution of selenium (Geological Survey of Wyoming Open File Report 88-1). Through the process of generating those reports, it became obvious that the Division's knowledge of selenium was limited. In order to better understand selenium, to aid ongoing research, and to prioritize future research projects, a selected bibliography on selenium is nearly completed. The selenium bibliography covers issues such as geology, geochemistry, human and animal health, soil and plant science, water, and mining and reclamation, among other topics. In fact, over 800 reports and books have been collected and included in the bibliography, which has an extensive index. Although the bibliography emphasizes Wyoming and surrounding states, research from around the world is included. This project was supported by a grant from the Wyoming Water Research Center at the University of Wyoming and the Governor's Office. The Geology Library at the University of Wyoming provided much assistance to the Division, and their help is appreciated. The bibliography should be available before the end of calendar year 1989.

The State Survey's Geologic Hazards Division has been actively mapping landslides over the entire state for the last eight years. From 1981-1982, all available reports and maps on Wyoming landslides were acquired and compiled, resulting in a series of 1:250,000-scale maps representing the compiled work as well as some limited field mapping. As a continuation of that project, the Survey initiated a mapping project of the entire state. From 1983 to present, over six hundred fifty 7 1/2-minute quadrangles have been mapped. The mapping primarily represents interpretation from aerial photographs. All major landslide areas, however, have been field checked. Landslide maps at a scale of 1:250,000 are nearly completed, and a text on slope movements in Wyoming is in progress. While the 1:250,000 scale maps are useful for regional planning and for getting a feel for regional landslide density and distribution, they are of limited value for site specific studies.

Because many inquiries directed to the State Survey require site specific data, another map series has been created, the Preliminary Landslide Map (PLM) series. These maps are primarily at a scale of 1:24,000 with a few at a scale of 1:62,500. The PLM series maps show landslide locations, boundaries, and classifications. The classifications include debris flows, earth flows, slumps, falls, rock slides, and rock fragment flows, among others. Eighty-nine maps in the series have been released to date, with most located in or near the Shoshone National Forest in northwest Wyoming. About 400 landslide maps generated over the last five years will be prepared as PLM's by the middle of 1992. The landslide project was in part funded by a grant through the U.S. Geological Survey's Landslide Hazards Reduction Program. For further information, contact the Geologic Hazards Division at the Geological Survey of Wyoming (Phone: 307-766-2286).

NEW PUBLICATIONS BY THE GEOLOGICAL SURVEY OF WYOMING

* Publications available from the Geological Survey of Wyoming, June, 1989

* Geologic map of the Leavitt Reservoir Quadrangle, by Karen Noggle-Perrin: Map Series 29, 1989, scale 1:24,000 ($4.00).

* Industrial minerals and construction materials map of the Powder River Basin and adjacent uplifts, Wyoming, by Ray E. Harris and Jon K. King: Map Series 30, 1989, scale 1:500,000 ($4.00).

* Index to selected U.S. Geological Survey bulletins that contain geologic maps for Wyoming, revision compiled by Phillip L. Greer and Alan J. VerPloeg: Map Series 9G, 1989, scale 1:1,000,000 ($2.50).

* Index to selected U.S. Geological Survey professional papers that contain geologic maps for Wyoming, revision compiled by Phillip L. Greer and Alan J. VerPloeg: Map Series 9H, 1989, scale 1:1,000,000 ($2.50).

* Index to U.S. Geological Survey topographic maps of Wyoming available from the Geological Survey of Wyoming (revision and reprint), 1989, scale 1:1,000,000 (one copy free).

* Preliminary geologic map of the Tallon Springs Quadrangle, Washakie and Johnson Counties, Wyoming, by Alan J. VerPloeg and Phillip L. Greer: Open File Report 89-5, 1989, scale 1:24,000 ($3.50).

* Preliminary geologic map of the Turk Springs Quadrangle, Washakie and Johnson Counties, Wyoming, by Alan J. VerPloeg and Phillip L. Greer: Open File Report 89-6, 1989, scale 1:24,000 ($3.50).

* Wyoming's oil and gas industry in the 1980s: a time of change, by Rodney H. DeBruin: Public Information Circular 28, 1989, 27 p. ($4.00).

* Preliminary Landslide Maps, by James C. Case and others, 1989, scales 1:24,000 and 1:62,500 ($3.00). This series will eventually include about 500 maps, and additions are in progress at this printing. Please call for availability of quadrangles not listed here.

Alder Lake
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Dunrud Peak
Eagle Creek
Eagle Peak
East Fork Basin
Esmond Park
Fall Creek
Fish Creek Park
Fish Lake
Five Pockets
Flag Peak
Fossil Hill
Francs Peak
Fremont Peak North
Fremont Peak South
Gannett Peak
Green River Lakes
Halls Mountain
Hardluck Mountain
Hays Park
Heart Lake

Huckleberry Mountain
Indian Point
Irish Rock
Kisinger Lakes
Lake Creek
Lava Mountain
Mount Hancock
Lizard Head Peak
Louis Lake
Milk Creek
Mount Arter
Mount Arter SE
Mount Bonneville
Mount Burwell
Mount Sheridan
Needle Mountain
Noon Point
Pat O'Hara Mountain
Pilot Peak
Pinnacle Mountain
Ptarmigan Mountain
Ramshorn Peak
Ranger Peak
Sheep Mesa
Sheridan Pass
Shoshone Pass
Snow Lake
Soapy Dale Peak
Sunlight Peak
Sunshine Reservoir
Sweetwater Gap
Sweetwater Needles
Temple Peak
Thorofare Buttes
Togwotee Pass
Twin Peaks
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Two Ocean Pass
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Wapiti
Warm Spring Mountain
Whetstone Mountain
Wiggins Peak
Wolf Point
Yellow Mountain
Younts Peak

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* New releases since the last issue of *Wyoming Geo-notes*.

Order these and other publications from: Geological Survey of Wyoming, Box 3008, University Station, Laramie, Wyoming 82071-3008. Phone: (307) 766-2286. Many of these publications are also available over-the-counter at the Wyoming Oil and Gas Conservation Commission (Basko Building) in Casper, Wyoming.

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— NEW SERVICE AVAILABLE —

By special arrangement with the Wyoming Geological Association (WGA), the Geological Survey of Wyoming now sells all of WGA's Annual Field Trip Guidebooks as well as its Symposium Volumes. These publications are available over-the-counter at the Survey's offices on the University campus in Laramie. Although they can be purchased by mail, prepayment is required. Call the Survey for book prices and postage costs. WGA sale prices will be honored also.

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