Chapter SM

BULL MOUNTAIN BASIN, MONTANA

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INTRODUCTION

The Bull Mountain Basin (fig. SM-1) is located in south-central Montana and contains coal of Tertiary age in the Fort Union Formation (fig. SM-2). The basin is an asymmetrical syncline which trends east-west, contains minor anticlines and synclines, and has beds that dip generally less than 5 degrees. Coal was produced continuously between 1907 and 1960 and between 1970 and mid-1997. However, the coal deposits in this basin have low importance in the current national coal resource assessment (Flores and others, 1998). Even though the Bull Mountain Basin contains coal of higher apparent rank than Powder River Basin coal, it is unlikely to become a major coal producer in the Northern Rocky Mountains and Great Plains Region within the next 20-30 years. This is because the basin is small, about 750 square miles (Woolsey, 1909), and the coal is thinner, less than 17 ft thick, than the major coal producers in the Powder River Basin (Flores and others, 1998).

STRATIGRAPHY

Because the Bull Mountain Basin and the Powder River Basin to the east were a single depo-center during late Cretaceous and early Tertiary time, they have similar stratigraphy. Post-deposition tectonics and erosion have isolated these basins (Pierce and others, 1983). Figure SM-2 shows the stratigraphic position of the major Tertiary coal beds in the Bull Mountain Basin (Woolsey and others, 1917; Connor, 1988). The Tertiary coal-bearing Fort Union Formation is of Paleocene age and it overlies the Upper Cretaceous Lance Formation. The lower 200-300 ft of the Fort Union Formation contains the Lebo Shale Member (fig. SM-

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2). The Tullock Member of the Fort Union Formation, which underlies the Lebo Shale Member to the east in the Powder River Basin, is not recognized in the Bull Mountain Basin. Woolsey and others (1917) reported that the Lebo Shale Member contains one coal bed called the Big Dirty, which is as thick as 17 ft near the middle of the member. The "upper part" of the Fort Union Formation, as defined by Woolsey and others (1917), is called the Tongue River Member (Connor, 1989), is a minimum of 1,650 ft thick, and contains 26 coal beds that range in thickness from 1 to 16 ft (fig. SM-2). The Fort Union Formation is overlain, in part, by Quaternary river terrace gravels and sandy alluvium. These deposits are as thick as 20 ft.

DESCRIPTION OF COAL

The Paleocene Fort Union Formation in the Bull Mountain Basin is considered a minor coal-bearing formation. The 200-300-ft-thick Lebo Shale Member has been described as the "somber-colored beds" by Richards (1910). Woolsey and others (1917) report the Lebo Shale Member consists of olive-green, yellow, brown, and dark-gray sandy-mudstone, sandstone, and coal. The only coal bed in the Lebo Shale Member, the Big Dirty, is the thickest coal bed in the Bull Mountain Basin, as much as 17 ft thick, but it is of no known economic interest because of the many clastic partings and splits; hence its name. The Big Dirty coal bed was studied and reported by Connor (1984). Connor notes that the numerous detrital layers in this bed are crystal tuffs and altered volcanic ash, which indicate a period of intense volcanism not recorded stratigraphically elsewhere in the Bull Mountain Basin. The Tongue River Member of the Fort Union Formation, which ranges in thickness from at least 1,650 ft to more than 2,050 ft, is composed of massive-yellowish to buff sandstone, light- to dark-gray mudstone, and coal. Aggregate thickness of coal in this member ranges from 20 to 85 ft. The Mammoth coal bed is near the middle of the Tongue River Member and is the thickest coal bed, from 5 to 16 (Connor, 1989). Detailed cross sections (1988) and isopach maps (1989) of the Mammoth coal bed were published by Connor. These cross sections and isopachs indicate that the Mammoth coal bed is split into as many as three beds and reaches maximum thickness only where there are no splits. Raw drill-hole and surface-section data for the Bull Mountain coal field are available in Connor and Biewick (1989). The Tongue River Member consists of fluvial-channel, overbank, and paludal deposits. Major streams flowed south (Shurr, 1972) to southeast (Connor, 1988) into the ancestral Powder River Basin.

COAL QUALITY

Connor (1989) reported that the Mammoth coal in the Bull Mountain Basin ranges in apparent rank from subbituminous A to high volatile bituminous C coal. Details of Mammoth coal quality are available in Connor (1989). Pontolillo and Stanton (1994) analyzed two samples from the basin. Those samples revealed a thermal maturity level of $\mathbf{R_{o\ max}}$ = 0.62 percent, and Daniel and Cole (1982) report an $\mathbf{R_{o\ max}}$ = 0.4-0.5 percent. These thermal maturity levels are consistent a with the apparent rank of subbituminous A to high volatile bituminous C coal for the Bull Mountain basin. Summary data for 18 coal-quality variables on table SM-1 were calculated for the entire Bull Mountain Basin using all public available data in the U.S. Geological Survey coal quality unpublished (USCHEM) database. A common problem in statistical summaries of trace-element data arises when element values are below the limits of detection. This results in a censored distribution. To compute unbiased estimates of censored data for the elements in this table, we adopted the protocol of reducing all “less than” values by 50 percent to generate a

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pseudo value for these data. Summary statistics of range (minimum and maximum value) and arithmetic means were generated using the modified data.

Between 1974 and 1994, the U.S. Geological Survey analyzed samples of coal for contents of major-, minor-, and trace-elements. Prior to performing the analyses, most of the coal samples were dried at room temperature and humidity for as much as 80 hours. Some samples, however, may have only been dried enough to allow grinding (to less than 100 mesh), and moisture contents of the samples are unknown, although moisture contents were probably similar to that which would remain after air-dry loss determination (American Society for Testing and Materials ASTM Standards, 1994, D3302-91). Since the actual moisture content of the samples analyzed between 1974 and 1994 is unknown, the elemental analysis of the samples cannot be converted to any other moisture basis. In addition, these analyses can only provide an approximation of load factors (such as, pounds of mercury per trillion Btu).

RESOURCES

Connor (1989) estimated the resources for the Mammoth coal bed, following the methodology of Wood and others (1983). The Mammoth coal bed contains 1,100 million short tons. Pierce and others (1983) estimated the resources of the Mammoth coal bed at 1,120 million short tons using the Kriging method (Mousset-Jones, 1980). Those are the only estimates available for the Bull Mountain Basin.

The other 24 beds have not been considered a resource by previous workers, although several of these beds have been mined.

PRODUCTION HISTORY

Coal has been mined commercially in the basin, but not continuously, since 1907 when the Republic Coal Company began operations on the Roundup coal bed (fig. SM-2) near Roundup, Montana (fig. SM-1). Production prior to 1907 was limited to a few tons per year, mined and utilized locally by the residents of the area for heating and blacksmithing. Total production, from 1926 to 1960 (fig. SM-3), is more than 23 million short tons (Montana Coal Council, written comun, 1998), mainly from underground mines on the Roundup and McCleary coal beds. The decision to mine these beds was probably influenced by proximity to rail transportation. Production figures prior to 1926 are not available; there was no commercial coal production during the 1960's. Coal production in the modern era began in 1970 mainly from surface mines. Total production from 1970 to 1997 was 740 thousand short tons (fig. SM-4) (Resource Data International, Inc., 1998), all from the Mammoth coal bed. The two production highs in 1990 and 1995 (fig. SM-4) are due to the first underground mine producing coal from the Mammoth coal bed.

CONCLUSIONS

Fort Union coal in the Bull Mountain Basin will not be a major source of coal in the next two decades. Although the Mammoth coal bed has been mined in the past and the quality (apparent rank, ash yield, and sulfur content, see table SM-1) is good, however, the small basinal area and thin beds indicate a low resource potential. On a positive note, infrastructure for rail transport of coal is in place, and if circumstances were good, minor amounts (minor when compared to projected Powder River production; Flores and others, 1998) of coal could be produced from the Bull Mountain Basin.

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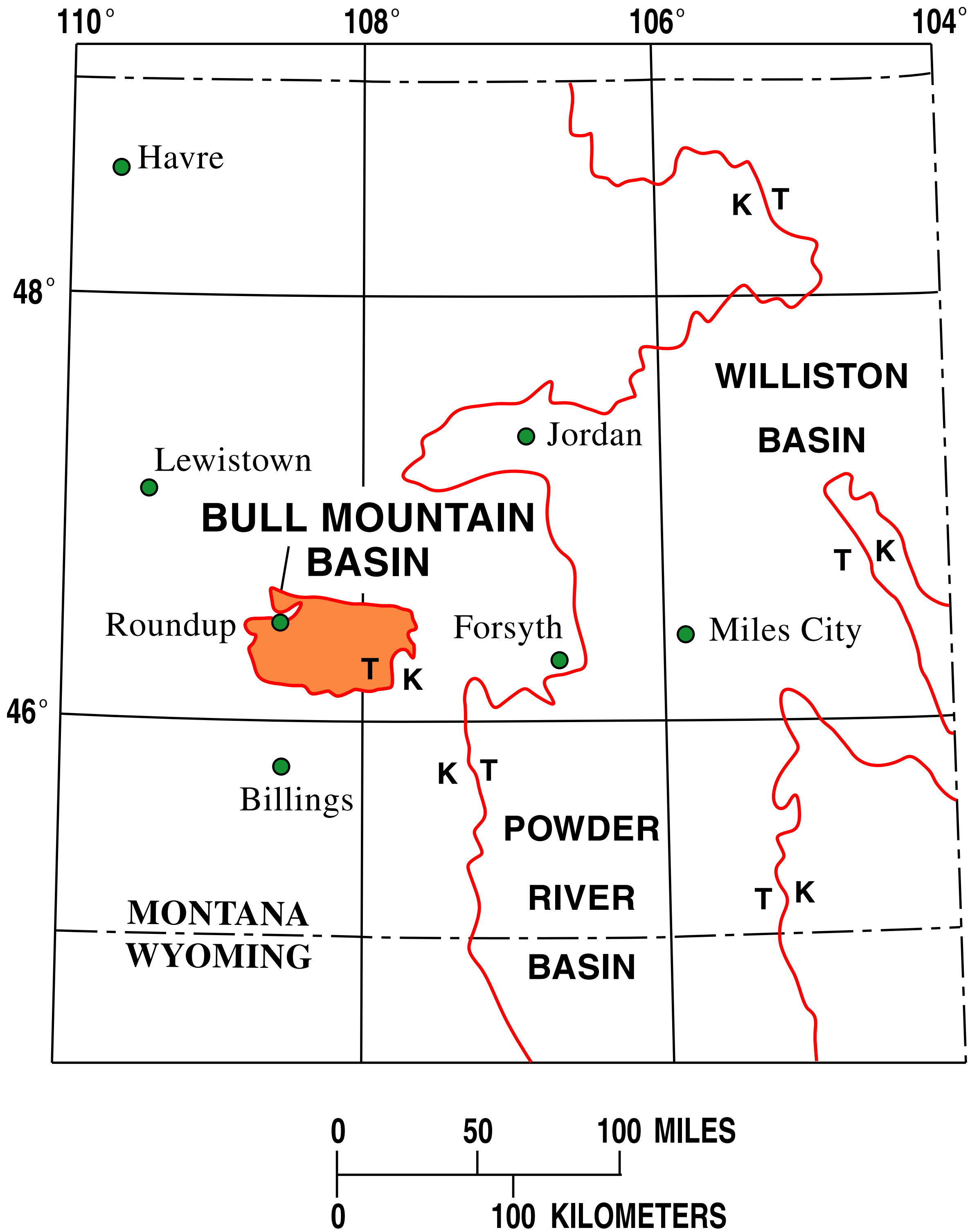

Figure SM-1. Location of the Bull Mountain Basin, south-central Montana. Bull Mountain Basin boundary drawn at the Lance-Fort Union boundary. "K" denotes Cretaceous rocks and "T" denotes Tertiary rocks (from Connor, 1989).

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SYSTEM	SERIES	FORMATION	MEMBER	COAL BED		THICKNESS OF COAL BEDS (in feet)	THICKNESS (in feet)
QUATERNARY	Holocene						0-20
TERTIARY	Paleocene	Fort Union	Tongue River	Unnamed coal		3-7	765± - 845+
				Summit		3	
				Fatig		3-4	
				Bull Mountain		2.5-6.5	
				Rock Mesa		2-7.5	
				Rehder split		0-5.5	
				Mammoth		5-16	890-1,210
				Dougherty		1.5-5	
				Buckley		0-6	
				Wildhorse		0-3	
				Roundup		0-6	
				McCleary		0-8	
				Carpenter		0-8	
			Lebo Shale	Big Dirty		2-17	200-300
CRETACEOUS (part)			Lance (part)				700-800

Figure SM-2. Generalized stratigraphy with principal coal beds in the Bull Mountain Basin, southeastern Montana (modified from Woolsey and others, 1917; Connor, 1989).

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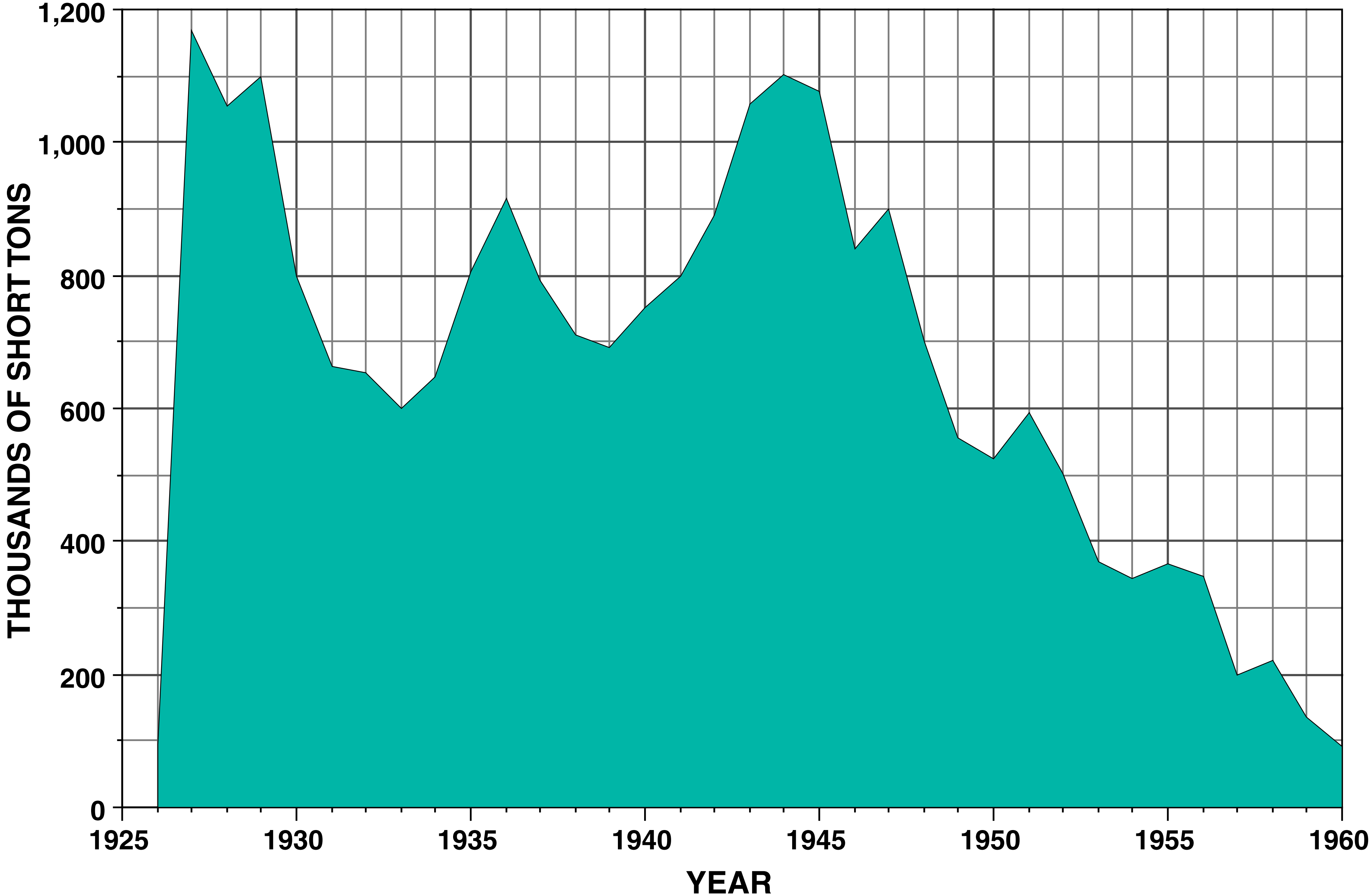

Figure SM-3. Coal production for the years 1926–1960, Bull Mountain Basin, Montana. Data from the Montana Coal Council (1998).

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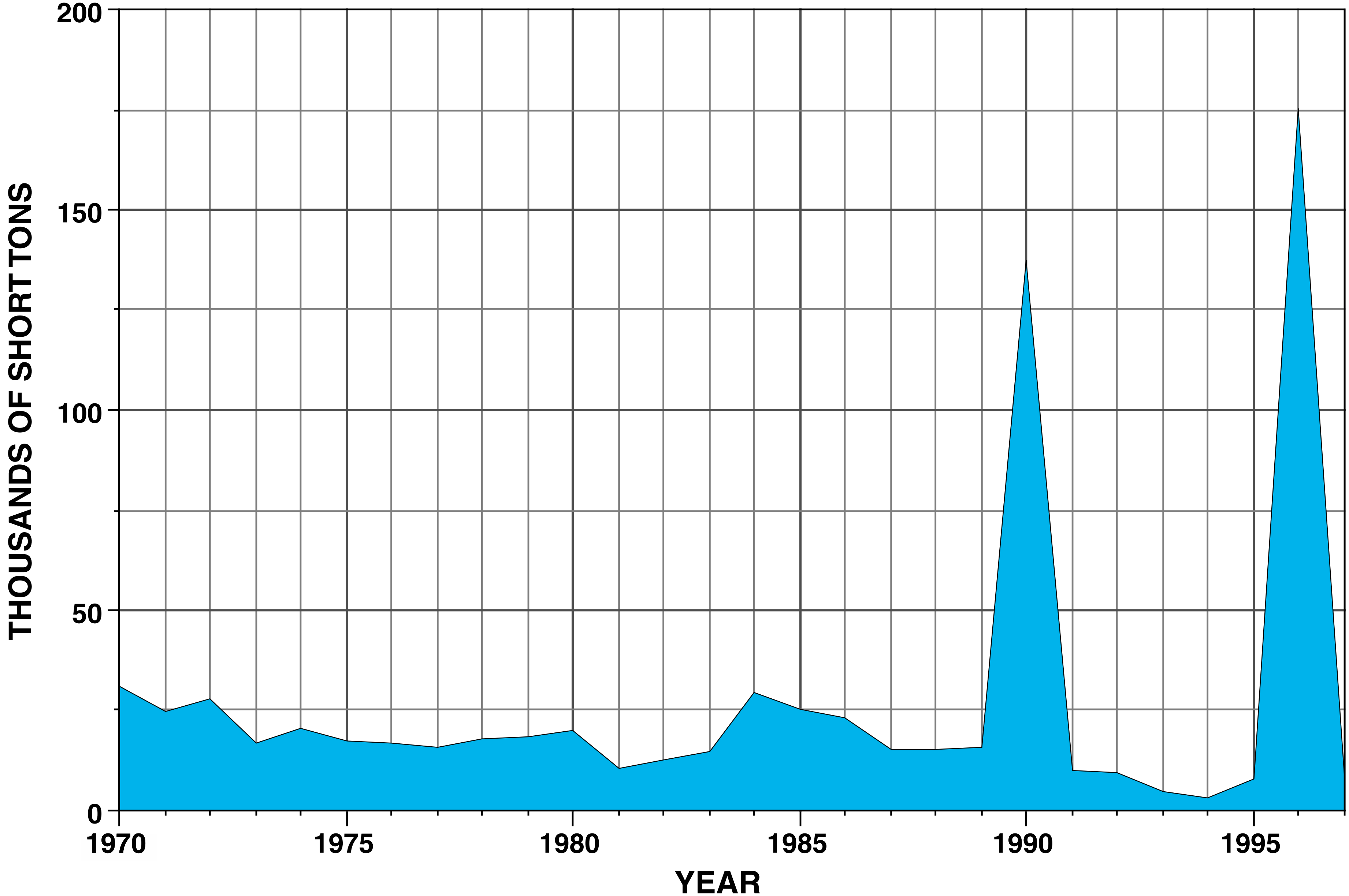

Figure SM-4. Coal production for the years 1970–1997, Bull Mountain Basin, Montana. Data from Resource Data International, Inc. (1998). Note change in vertical scale from that in figure SM-3.

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Table SM-1. Summary of coal quality for all coal in the Bull Mountain Basin, Montana. Calculated from the unpublished U.S. Geological Survey coal quality database (USCHEM), February, 1992 and Connor (1989)

Variable	Number of samples	Range: Minimum	Range: Maximum	Mean
Moisture [1]	12	9.6	32.00	17.21
Ash [1]	12	5.60	10.40	8.32
Total sulfur [1]	12	0.50	1.20	0.82
Calorific value [2]	12	5,760	10,990	9,760
lb SO_2 [3]	12	1.09	2.46	1.70
MMMFBtu [4]	12	6,400	12,160	10,730
Antimony [5]	9	0.37	9.1	1.7
Arsenic [5]	9	1.0	35	7.0
Beryllium [5]	11	0.42	1.9	0.73
Cadmium [5]	12	0.066L	0.18	0.077
Chromium [5]	9	2.6	6.5	3.6
Cobalt [5]	9	0.65	5.5	1.4
Lead [5]	12	2.3L	34	6.7
Manganese [5]	12	8.3	130	41
Mercury [5]	12	0.040	0.28	0.11
Nickel [5]	12	0.66	9.0	2.7
Selenium [5]	7	0.48	0.98	0.75
Uranium [5]	12	1.1	6.8	1.8

[1] Value is in percent and on an as-received basis.
[2] Value is in British thermal units (Btu).
[3] Value is in pounds per million Btu and on an as-received basis.
[4] Value is in British thermal units on a moist, mineral-matter-free basis.
[5] Value is in parts per million (ppm) on a whole-coal and as-received basis; ✌L✍ denotes less than value shown.