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Lance Cook, State Geologist

BALLAST IN WYOMING

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Illustration

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Introduction

Ballast is an end use term for crushed aggregate used specifically for weighting and holding railroad ties in place. This material must allow for some movement as a train passes with minimum wear or breakdown of the material. Ballast must also be nonmagnetic and have high electrical resistance so as not to affect train detection systems that use magnets as detectors. Sub-ballast is the material making up the top of the roadbed . It must also be nonmagnetic and is sized for maximum resistance to wear, durability and to allow for the drainage of water. Light-duty ballast of different specifications is used on branch lines and in yards. The locations of ballast and sub-ballast quarries are trade-offs between the quality (wear-resistance and uniform crushability) of the ballast versus transportation costs.

The two railroads operating in Wyoming produce ballast in Wyoming. The Union Pacific Railroad purchases ballast from Martin-Marietta Materials and uses this Wyoming ballast on their rail lines east to their terminus in Council bluffs, Iowa, and west into Utah. The Union Pacific's former Chicago North Western lines in east-central Wyoming also use this ballast, though ballast from Neosho Construction's Bald Butte Locality has also been used. The Burlington Northern Railroad also purchases for ballast from Martin-Marietta Materials, and also uses a dolomitic marble from Peter Kiewit, Inc., the operators of the Guernsey stone quarry, for lighter-duty ballast.
Many types of rock can be used for ballast. Areas in Wyoming containing stone (see Harris, 1996) that can be crushed in to equidimensional pieces and meets other specifications may qualify for ballast. Transportation costs, amount of rock available and processing costs must then become the prime factors in determining the suitability of a rock to be used for ballast.

As an example of the requirements necessary for ballast, the following specifications were developed by the former Chicago North Western Railroad for ballast :

> Ballast shall consist of one of the following crushed aggregates: granite; quartzite; other sound igneous rock; Precambrian siliceous dolomite; or quality equivalent.
> *Authors note – recent silica restrictions in federal regulations have removed quartzite from use as ballast, and quartzite ballast sources in Minnesota have closed.

Ballast shall be in accordance with the following gradation:

Total percent by weight retained on sieve

Sieve size	Percent retained
2-inch	0
1 ½-inch	0-10
1-inch	45-80

¾-inch	85-100
3/8-inch	95-100

The gradation shall be determined by the test with laboratory sieves having square openings and conforming with the American society of Testing Materials (ASTM) Specifications, designation E11.

Aggregates shall have a soundness loss of not more than seven percent by weight at the end of five cycles using sodium sulfate solution.

Deleterious substances shall not be present in the ballast in excess of the following amounts:

Soft particles	1.5%
Material finer than No. 200 sieve	1.0%
Clay lumps and friable particles	0.5%

The percentage of wear of processed ballast, tested in the Los Angeles abrasion machine, shall not be greater than 30 percent.

The percentage of weight of flat or elongated particles permitted in the ballast shall not exceed five percent. Flat or elongate particles are defined as particles having a length that is equal to, or greater than, five times the average thickness.

Ballast shall not produce fines (upon degradation) that will become cemented with time.

Sampling and testing shall be performed in accordance with the current edition of the methods listed below:

a) Sampling – ASTM D 75;
b) Sieve analysis – ASTM C 136;
c) Material finer than the No. 200 sieve – ASTM C 117;
d) Percentage of soft particles – ASTM C 851;
e) Percentage of clay lumps and friable particles – ASTM C 142;
f) Resistance to abrasion using standard grading most nearly representative of the size of the ballast specified – ASTM C 131 or ASTM C 535;
g) Soundness Test – ASTM C 88;
h) Weight per cubic foot – ASTM C 29.

Sub-ballast has slightly different requirements. For example, the following specifications are required by the Chicago North Western Railroad for sub-ballast:

Sub-ballast shall consist of one of the following crushed materials, with or without fines: granite; quartzite; other sound igneous rock; Precambrian siliceous dolomite; sand, gravels and boulders.

The composition of the sub-ballast may vary along the project depending on the proximity of aggregate sources; however, daily production shall be of one kind of sub-ballast at a time. All crushed aggregates from a single source shall be the same type of material.

Sub-ballast shall be in accordance with the following gradation:

a) Single Aggregate Sub-Ballast

Total Percent by Weight Retained on Sieve	Percentage (%)
1-inch	0
¾ inch	0-5
3.8 inch	4-40
No. 10	50-74
No. 40	70-90
No. 200	90-97

b) The gradation shall be determined by test with laboratory sieves having square openings and conforming with ASTM E 11.
c) The gradations shown in the table are the extreme limits which determine suitability for use. The produced aggregate shall be reasonably uniform and consistent and not subject to extreme variations from the midpoint of the allowable percentage shown in said Table.

Aggregate retained on the No. 10 sieve shall consist of hard, durable particles or fragments of stone, gravel or sand; aggregate that shall not break up when alternately frozen and thawed or weed and dried. These aggregates shall have a percentage of wear not greater than 40 percent when tested in the Los Angeles abrasion machine.

Aggregates shall have soundness loss of not more than ten percent by weight at the end of five cycles using sodium sulfate solution.

The sub-ballast shall meet the requirements specified herein and allow for construction of a stable platform upon which the track and ballasting work for the project can be completed.

Sampling and testing shall be performed in accordance with the current edition of the methods listed below:

a) Sampling – ASTM D 75;
b) Sieve analysis – ASTM C 136;
c) Material finer than the No. 200 sieve – ASTM C 117;
d) Liquid limit – ASTM D 423;
e) Plasticity limit – ASTM C 424;
f) Resistance to abrasion using standard grading most nearly representative of the size of the sub-ballast specified – ASTM C 131 or ASTM C 535;
g) Soundness Test – ASTM C 88;
h) Weight per cubic foot – ASTM C 29.

The following specifications required by the Union Pacific Railroad fro mainline and light-duty and yard ballast are shown on the following tables:

Union Pacific Railroad Company
Limiting Test Values
For Maintrack Ballast

Property	Ballast Material					ASTM Test
	Granite	Taprock	Quartzite	Limestone	Dolomitic Limestone	
Percentage Material Passing No. 200 Sieve	1.0%	1.0%	1.0%	1.0%	1.0%	C 117
Bulk Specific Gravity (see note #2)	2.70%	2.70%	2.70%	2.70%	2.70%	C 127
Absorption Percent	.5	.5	.5	.5	.5	C 127
Clay Lumps and Friable Particles	.5%	.5%	.5%	.5%	.5%	C 142
Degradation (LAA + 5MA)	50%	50%	50%	45%	45%	See Note #1
Soundness (Sodium Sulfate) 5 cycles	2.0%	2.0%	2.0%	2.0%	2.0%	C 88
Flat and/or Elongated Particles	5.0%	5.0%	5.0%	5.0%	5.0%	USAGE CRD-C 119
Plasticity Index (LA Fines)	NP	NP	NP	NP	NP	D 423, D 424
Total Sample Liquid Limit	25	25	25	25	25	D 423, D 424
Total Sample Plasticity Index	6	6	6	6	6	D 423, D 424

Note #1 – Materials corresponding to gradation #4-A shall have that portion retained on the one inch sieve by ASTM C 535; materials corresponding to gradation numbers 4, 5 and 57 shall have those portions retained on the #4 sieve tested by the ASTM C 131.

Note #2 – The limit for bulk specific gravity is a minimum value. Limits for the remainder of the tests are maximum values.

Union Pacific Railroad Company
Limiting Test Values
Branch and Yard Ballast

Property	Ballast Material					ASTM Test
	Granite	Taprock	Quartzite	Limestone	Dolomitic Limestone	
Percentage Material Passing No. 200 Sieve	1.0%	1.0%	1.0%	1.0%	1.0%	C 117
Bulk Specific Gravity (see note #2)	2.60%	2.60%	2.60%	2.60%	2.60%	C 127
Absorption Percent	.5	.5	.5	.5	.5	C 127
Clay Lumps and Friable Particles	.5%	.5%	.5%	.5%	.5%	C 142
Degradation (LAA + 5MA)	65%	65%	65%	60%	60%	See Note #1
Soundness (Sodium Sulfate) 5 cycles	5.0%	5.0%	5.0%	5.0%	5.0%	C 88
Flat and/or Elongated Particles	5.0%	5.0%	5.0%	5.0%	5.0%	USAGE CRD-C 119
Plasticity Index (LA Fines)	NP	NP	NP	NP	NP	D 423, D 424
Total Sample Liquid Limit	25	25	25	25	25	D 423, D 424
Total Sample Plasticity Index	6	6	6	6	6	D 423, D 424

Note #1 – Materials corresponding to gradation #4-A shall have that portion retained on the one inch sieve by ASTM C 535; materials corresponding to gradation numbers 4, 5 and 57 shall have those portions retained on the #4 sieve tested by the ASTM C 131.

Note #2 – The limit for bulk specific gravity is a minimum value. Limits for the remainder of the tests are maximum values.

Union Pacific Railroad Company
Ballast Gradation

Size No.	Nominal Size Square Opening	Percent Passing									
		3"	2 ½"	2"	1 ½"	1"	¾"	½"	3/8"	No. 4	No. 200
4-A	2"-3/4"		100	90-100	60-90	10-35	0-10		0-3		
4	1 ½"-3/4"				90-100	45-55	15-25	0-12	0-3		
5	1"-3/8"				100	90-100	40-75	15-35	0-15	0-5	
57	1"-No. 4				100	95-100		25-60	70-90	0-5	0-1

Note #1 – Gradation Number 4;A and 4 are main track ballast materials. Gradation Numbers 5 and 57 are branch and yard ballast materials.

PRODUCING QUARRIES

(The number preceding each quarry description refers to the number on the map, page 10).

Albany County

1. Union Pacific Railroad Morrison-Knudsen Quarries
   Secs. 3 and 10, T.14n., R. 71 W.

Morrison-Knudsen Company operated a ballast quarry for the Union Pacific railroad at these localities. Coarse-grained Sherman Granite (Precambrian) was quarried in the Albany County locations, crushed and sized at Granite Canyon and shipped on railroad maintenance-of-way ballast cars.

Campbell County

2.Burlington Northern Railroad, Wyodak Clinker Quarries
Sec. 19 and 20, T.50N., R.71W., east of Gillette

Clinker (baked and fused rock) was quarried at this location by the Chicago, Burlington, and Quincy Railroad and later by the Burlington Northern Railroad for use as ballast. Most of the production was used locally on lines in the Powder River Basin serving the coal mines near Gillette. Production from this quarry is summarized in the following table (Wyoming Department of Revenue and Taxation, Ad Valorem Tax Division annual reports).

Year	Production (short tons)
1985	334
1984	2,373
1983	0
1982	95,745
1981	156,357
1980	74,940
1979	54,514
1978	99,712
1977	41,322
1976	62,010
1975	52,869

Laramie County

Martin-Marietta Materials Granite Canyon Quarry
Secs. 4,5,6,7,8,9,16,17 and 18, T.13N., R.69W.

Martin-Marietta Materials Company operates a large ballast quarry, gyratory crusher and sizing screens at Granite canyon. This quarry has been the prime source of ballast on the Union Pacific Railroad in Wyoming and Nebraska since 1944, and the Burlington Northern Railroad since the late 1980s. The rock quarried is a dark coarse-grained granite gneiss. The following table summarizes production from these quarries (State Inspector of Mines of Wyoming annual reports). Not all of this production is railroad ballast. Since about 1990, construction aggregate of various sizes has also been produced. This is Wyoming's largest aggregate quarry. From 1994 through 1996, some of this material was used in the construction of Denver International Airport.

Year	Production (short tons per year)
1991	2,148,920
1992	2,798,595
1993	2,640,234
1994	Not reported
1995	2,735,222
1996	3,175,600
1997	2,733,761
1998	3,363,667
1999	3,363,667
2000	3,457,631
2001	3,116,760

Niobrara County

3.Neosho Construction Company, Inc., Chicago and North Western Railroad Company, Bald Butte Quarry

Sec. 31, T.31N., R.63W

Neosho Construction Company operates a quarry at this locality for the Chicago North Western Railroad (C&NW). This quarry produced 299,958 short tons of ballast in 1983, its first year of operation, and 1,247,169 short tons of ballast in 1984 (Wyoming Department of Revenue and Taxation, Ad Valorem Tax Division annual reports). The rock quarried is Archean granite (Love and others, 1980). The ballast was used on the C&NW (now Union Pacific) Railroad's lines from Morrill, Nebraska, to Lusk, and from Orin Junction to the Powder River Basin coal fields. The line between Lusk and Orin Junction was upgraded using this ballast.

4. SW1/4NW1/4 sec. 25, T.32N., R.64W.

Neosho Construction Company operated a quarry at this location in 1982 and 1983. Rock exposed in the quarry beneath a thin alluvial and Tertiary covers

is the Guernsey Limestone (Mississippian-Devonian) (Love and others, 1980). Some of the production from this quarry was used as ballast or sub-ballast by Chicago North Western Railroad during upgrading and new track construction in those years (see locality 3).

5. N1/2 sec. 16, T.32N., R.65W.

Neosho Construction Company operated a quarry in this location. The rock in the quarry is a dolomitic limestone in the Permo-Pennsylvanian Hartville Formation (Love and others, 1980). Some of the production from this quarry was used as ballast or sub-ballast by the Chicago North Western Railroad (see locality 3).

Platte County

6.Guernsey Stone Quarry

S1/2 sec., 25 T.27N., R.66W.

Peter Kiewit, Inc., operates a quarry at this location under the subsidiary name Guernsey Stone. Some of their production is used as ballast by the Burlington Northern Railroad. The rock is a Precambrian dolomite (Snyder, 1980). Rock from this quarry is also used as aggregate for purposes other than railroad ballast.

OTHER PRODUCTION

Lincoln County

7. Leefe Phosphate Plant

Secs. 10, 11, 14, 15, T.21N., R.120W.

Spent shale from the production of phosphate at this plant was used as ballast by the Union Pacific Railroad in western Wyoming and on certain other light-duty railroad lines including the Coalmont Branch from Laramie to Coalmont in North Park, Colorado (D.L. Blackstone, University of Wyoming, personal communication, 1985 and T.E. Sharps, Rocky Mountain Energy Company, personal communication, 1985).

PROSPECTS

Campbell County

8. Gillette Area

T.50N., Rs.71. and 72W.

Extensive outcrops of clinker (baked and fused rock) are present in this area. This rock was used for ballast as recently as 1984 from a quarry in secs. 19 and 20, T.50N., R.71W. (see locality 2 page 12). Although of lower quality than rock elsewhere, its proximity to transportation may make this rock economical fro use as ballast in the local area.

Carbon County

9. Rawlins Uplift

T.21n., Rs.87 and 88W.

Outcrops of the upper part of the Cambrian Flathead Formation, a dense, hard orthoquartzite, may be suitable for ballast. Precambrian granitic igneous rock in the western part of the Rawlins Uplift may also be suitable for ballast. This are is adjacent to or within three miles of the Union Pacific Railroad.

Laramie County

10.Horse Creek area

W1/2 T.17n., R.70W.

The Sherman Granite (Precambrian) crops out west of the Horse Creek limestone quarries. Areas of this rock are similar to those being quarried by the Union Pacific railroad in Albany and Laramie County for ballast (see locality 1, page 11). Rock from this area was tested fro ballast by the Burlington Northern Railroad in 1984, and fond to be suitable, although it was too far from the Horse Creek siding to be economical, (H.E. Reed, Meridan Minerals Company, personal communication, 1985).

Niobrara County

11. Lusk area

Ts.32 and 33N., Rs.63,64 and 65W.

In this area, outcrops of Precambrian igneous and metamorphic rocks, the Flathead Formation (Cambrian), the Guernsey Limestone (Mississippian and Devonian), Mississippian(?) or Pennsylvanian(?) quartzites and the Hartville Formation (Permian-Pennsylvanian) crop out in place where the Tertiary cover has been eroded. These rocks may be locally suitable for ballast.

Platte County

12.Guernsey area

Secs. 5 and 6, T.26N., R.65W.

Rocks of Precambrian age crop out in these sections and have been quarried fro ballast in the past. Qauternary terrace gravel in the north half of these sections was also used for ballast (Aalberg, 1945).

13. Colorado Fuel and Iron Company, Sunrise Mine area
SW1/4SW1/4 sec. 5, SE1/4SE1/4 sec.6
NE1/4NE1/4 sec.5 and NW1/4NW1/4 sec. 8,
T.27N., R.68W.

Quartzite of Mississippian(?) or Pennsylvanian(?) age crops out over a wide area. The rock rests on a paleokarst surface and is variable in thickness, though exposures in this area show a thickness that varies from 80 to 200 feet. After completing testing on the rock, the Burlington Northern Railroad proposed to open a ballast quarry at this site. Present plan (1986) call for upgrading the rail line (Colorado and Wyoming Railroad) from north of Guernsey to the abandoned Sunrise iron mine and using this line to transport ballast from the quarry and processing area at Sunrise to the Burlington Northern main line at Guernsey.

14.Two Bar Ranch Area
NW1/4 sec. 27, T.32N., R.69W.

Precambrian granitic rock at this location was found to be the highest grade ballast tested in Wyoming by the Burlington Northern Railroad in their ballast search in 1984-1985. Adequate reserves are present in the area. The location of this rock, which is eight miles from the nearest rail line (in Wheatland), however, precluded consideration for development at that time (H.E. Reed, Meridan Minerals Company, personal communication, 1985). However, in 2001, feasibility studies continued towards the development of this site (Mitch Albert, personal communication, 2001)

References

Aalberg, H.A., 1945, Purchase land in sections 5 and 6, T.26N., R.65W., east of Guernsey, Wyoming: Chicago, Burlington and Quincy Railroad unpublished company map (Geological Survey of Wyoming files), scale 1:12,000.

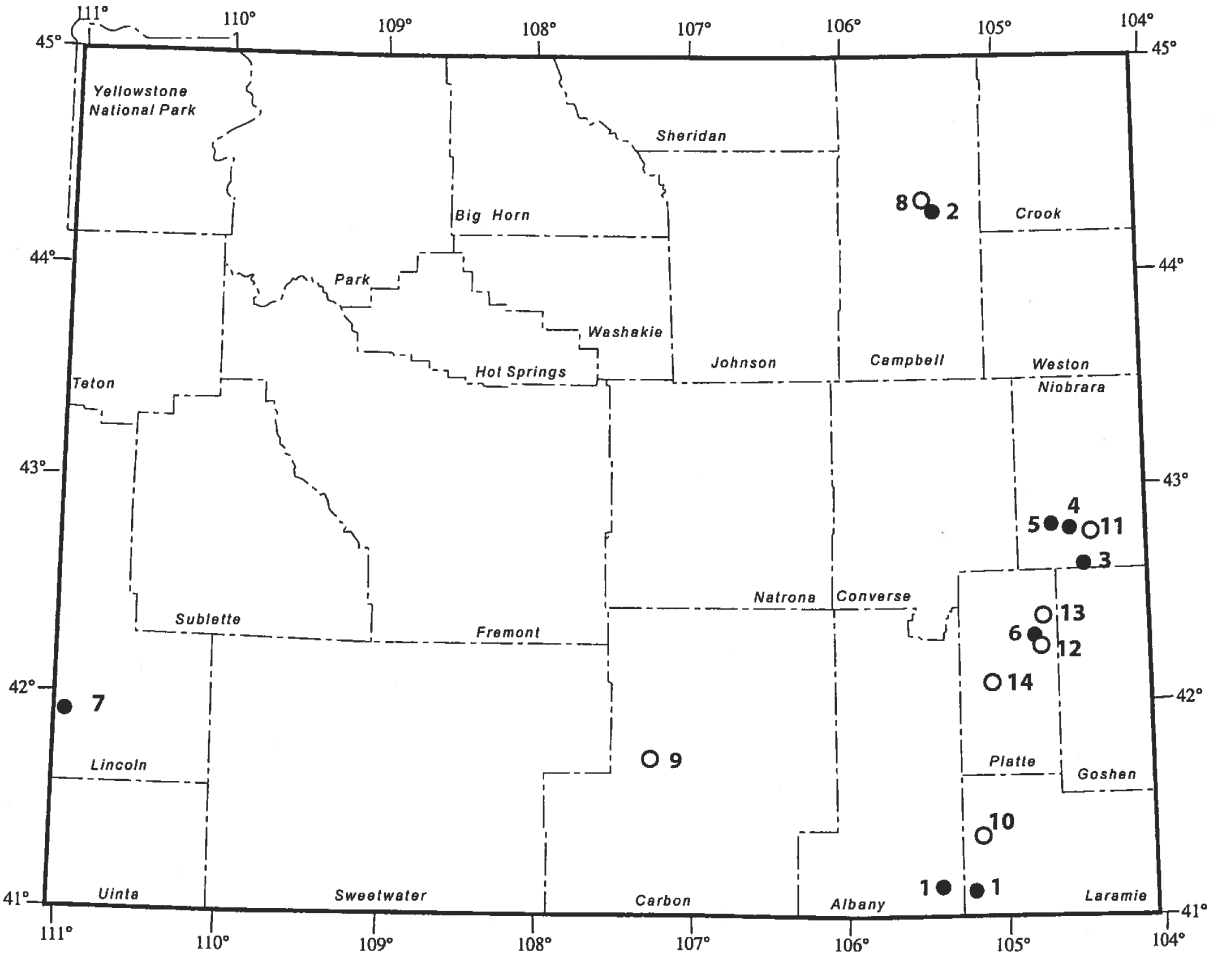
Harris, R.E, 1996, Industrial Minerals and Construction Materials map of Wyoming: Wyoming State Geological Survey Map Series 47, scale 1:500,000, color.

Love, J.D., Christiansen, A.C., and Sever, C.K., 1980, Geologic map of the Torrington 1° x 2° Quadrangle, southeastern Wyoming and western Nebraska: U.S. Geological Survey Miscellaneous Field Studies Map MF-1184, scale 1:250,000.

Snyder, G.L., 1980, Map of Precambrian and adjacent Phanerozoic rocks of the Hartville uplift, Goshen, Niobrara and Platte Counties, Wyoming: U.S. Geological Survey Open File Report 80-779 11p., 2 plates.

State Inspector of Mines of Wyoming Annual Reports, 1992 – 2002 (production from 1991 – 2001), Rock Springs, Wyoming.

Wyoming Department of Revenue and Taxation, Ad Valorem Tax Division, Annual reports 1975-1986: Cheyenne, Wyoming.



Producing localities

1. Martin-Marietta Materials quarries
2. Burlington Northern Inc., clinker quarry
3. Neosho Construction Company Inc., Bald Butte quarry
4. Neosho Construction Company Inc., ballast quarry
5. Neosho Construction Company Inc., ballast quarry
6. Guernsey Stone quarry
7. Leefe Phosphate Plant (spent shale)

Prospects

8. Gillette area
9. Rawlins uplift
10. Horse Creek area
11. Lusk area
12. Guernsey area
13. Colorado Fuel & Iron Company Sunrise Iron Mine area
14. Two Bar Ranch

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EXPLANATION

● Producing quarries and localities

○ Prospects

Miles
0 50
0 60
Kilometers

Index map showing ballast producing localities and prospects.