INTRODUCTION
PURPOSE OF INVESTIGATION
This report summarizes information on the thickness, grade, lateral continuity, phosphate resources, and ownership of phosphate-bearing units in the Meade Peak Phosphatic Shale Member of the Phosphoria Formation in the Stewart Flat quadrangle. This report is one of a series of quadrangle reports prepared by the Idaho Bureau of Mines and Geology under U.S. Geological Survey cost-sharing contract #14-08-0001-17925 to calculate phosphate resources in southeastern Idaho (fig. 1).

ACKNOWLEDGMENTS
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METHODS OF INVESTIGATION
The Stewart Flat quadrangle phosphate resource maps are based on published and unpublished data from industry, state, and federal sources. The interpretation of the structure of the Meade Peak Phosphatic Shale Member in the subsurface is based on cross sections constructed from U.S. Geological Survey and phosphate company geologic maps, cross sections, and drill-hole and trench logs, supplemented by discussions with Bureau of Land Management and company geologists. Phosphate rock thickness and P₂O₅ assay values are used from only those drill holes and trenches whose locations can be accurately plotted for elevation and land coordinates. Structure contours and overburden isopachs on the stratigraphic top of the Meade Peak are extended 600 feet along strike from the last known exposure of the Phosphoria Formation and are extrapolated to a depth of 1,500 feet. Phosphate resources of the Meade Peak are calculated for three categories of overburden thickness: 0 to 300 feet, 300 to 600 feet, and 600 to 1,500 feet (fig. 2).

Identified phosphate resources (U.S. Bureau of Mines and U.S. Geological Survey, 1980) are computed for the upper and lower phosphate units of the Meade Peak (fig. 3). Resource tonnages were determined according to the method used by Montgomery and Cheney (1967, p. 41) and Oberlindacher and Howland (1979, p. 7). For the Stewart Flat quadrangle, more than forty resource blocks (not shown on the map sheets) were constructed based on structural similarities. The volume (V) of phosphate resource in each block is calculated by multiplying the true area of the stratigraphic top of the Meade Peak by the cumulative average thickness (t) of the upper and lower phosphate units. The true area is the planimetered map surface area (A) of each block multiplied by the secant of the average dip (d) of the Meade Peak (fig. 4):

\[ V = A \times \sec d \]

Resource tonnages (R) are calculated by multiplying the volume (V) of phosphate resource by the average density (ρ) of the phosphate rock:

\[ R = V \times \rho \]

An average density of 0.0787 short tons per cubic foot, derived from Oberlindacher and Howland’s (1979) average density value of 2.52 metric tons per cubic meter, is applied to convert the volume of phosphate resource (calculated in cubic feet) to short tons of phosphate resource (sheets 2 and 3).

Thickness, phosphate content, and stratigraphic position are the three factors that determine whether a sampling interval is included within the phosphate units to calculate resource tonnages. A “sampling interval” is a rock sample of known thickness and phosphate content, as derived from a drill hole or trench log. In this report, the Meade Peak is subdivided into five informally named units based on Hale’s (1967) subdivisions of a typical section in the upper Dry Valley area, Caribou County, Idaho (fig. 3). These units are, from bottom to top: the lower waste, the lower phosphate, the middle waste, the upper phosphate, and the upper waste. The only units considered in the resource calculations in this report were the lower and upper phosphate units (fig. 3). Isolated minor phosphorite beds in the waste units are excluded from consideration.

The following guidelines used in this report to define phosphate units are based on Montgomery and Cheney (1967), Oberlindacher and Howland (1979), and generally accepted phosphate mining practices in southeastern Idaho:

1. The upper and lower boundaries of the phosphate units are defined by the uppermost and lowermost sampling intervals that are 1 foot or more thick and contain at least 16 percent P₂O₅, except where adjoining sampling intervals less than 1 foot thick with 16 or more percent P₂O₅ are added together to meet the 1-foot thickness requirement. Within a phosphate unit, all sampling intervals with 16 or more percent P₂O₅ are included in the resource calculation regardless of thickness.

2. Within the phosphate units, sampling intervals and sequences of contiguous sampling intervals containing less than 16 percent P₂O₅ and measuring at least 2 feet thick are excluded from the resource calculation.
Within the phosphate units, isolated sampling intervals less than 2 feet thick with less than 16 percent $P_2O_5$ are included in the resource calculation.

The information about ownership of surface and phosphate rights was obtained for Federal lands from the U.S. Bureau of Land Management’s leaseable mineral and master title plats and for State lands from the Idaho Department of Lands’ land plats. These sources also were used to locate Federal phosphate leases, Preference Right Lease Applications (PRLAs), Known Phosphate Leasing Areas (KPLAs), and State phosphate leases. Titles to surface and phosphate rights on private land are from both the Federal and State plats. Private phosphate leases, leases on land with private title to both surface and phosphate rights, are not shown.

**LOCATION AND TOPOGRAPHY**

The Stewart Flat quadrangle is about 19 miles east of Soda Springs, Idaho (fig. 1). The quadrangle boundary includes parts of Tps. 8 and 9 S., Rs. 44, 45, and 46 E., Boise Principal Meridian. The area is accessible by graveled roads.

Major topographic features in the quadrangle include the north-trending Webster Range, Freeman Ridge, Stewart Flat, and Dry Ridge. Diamond Creek and its tributaries drain most of the area between Webster Range and Dry Ridge. Draney Peak in the Webster Range and Freeman Pass on Freeman Ridge are also prominent features. Elevations range from 6,670 feet on the west flank of Dry Ridge to 9,131 feet at Draney Peak.

**FEDERAL LAND STATUS**

The Federal government holds phosphate and surface
FIGURE 2.—Diagrammatic cross section showing identified phosphate resources of the Meade Peak Phosphatic Shale Member of the Phosphoria Formation.
FIGURE 3.— Typical Permian section, upper Dry Valley area, Caribou County, Idaho (from Hale, 1967).

The areas of double and triple overlap represent areas where the Meade Peak is folded under itself once or twice at depth. These areas were measured as much as three times to account for all of the identified phosphate resources. Structural contours are not shown for the overturned portions of the Meade Peak on Dry Ridge. The western limit of the overturned Meade Peak is projected to the surface to show how far west the unit extends before returning to a normal dip.

MINERALOGY AND GEOCHEMISTRY

Altered phosphorite within the Meade Peak Phosphatic Shale Member consists, for the most part, of medium-grained, rounded pellets of microcrystalline apatite aggregates (Emigh, 1958; Gulbrandsen, 1966). Typical Meade Peak phosphorite is approximately 80 percent apatite, 10 percent quartz, 5 percent muscovite-illite, 2 percent organic matter, 1 percent dolomite-calcite, 1 percent iron oxide, and 1 percent other components (Gulbrandsen, 1966).
Explanation and sequence of calculations:

1. \( V_a = A_a \cdot t \)  
2. \( R_a = V_a \cdot P \)

- **\( V_a \)**: volume of resources under less than 300’ of overburden
- **\( A_a \)**: measured map surface area of resources under less than 300’ of overburden
- **\( t \)**: cumulative average thickness of the upper and lower phosphate units
- **\( d \)**: average dip of the Meade Peak Phosphatic Shale Member of the Phosphoria Formation

**Explanation and Sequence of Calculations**

\( V_a = A_a \cdot t \)  
\( R_a = V_a \cdot P \)

**FIGURE 4.** — Block diagram showing method of calculating phosphate resources.

According to Gulbransen (1966), the apatite is a fluorapatite, \( \text{Ca}_5(\text{PO}_4)_3\text{F} \), with sodium substituting for calcium, and carbonate and sulfate substituting for the phosphate radical. Also substituting, to a lesser extent, for calcium are strontium, uranium, thorium, yttrium, lanthanum, neodymium, and ytterbium. Pelletal and oolitic phosphate beds with greater than 31 percent \( \text{P}_2\text{O}_5 \) and greater than 3 feet in thickness generally contain 0.01 to 0.02 percent uranium (McKelvey and Carswell, 1967). Several elements—arsenic, cadmium, chromium, copper, molybdenum, nickel, antimony, selenium, vanadium, zinc, and silver (?)—occur in the organic fraction of the phosphorite (Gulbransen, 1966).

Vanadium occurs within several shale and mudstone beds of the Meade Peak. One zone of economic interest (about 5 to 10 feet below the upper phosphate unit) averages 4 feet in thickness and 0.7 percent vanadium pentoxide, and is associated with small amounts of selenium, molybdenum, zinc, nickel, cobalt, titanium, and cadmium (Love, 1967). Desborough (1977) found vanadium in, or associated with, organic material in leached samples from thin beds of vanadium-rich shale and mudstone in phosphate-rich zones; chromium in a 10-A mica in unleached phosphate nodule samples; zinc and cadmium in sphalerite; silver associated with the organic material and not as a silver sulfide phase; selenium in pyrite; sulfur in pyrite, sphalerite, and the organic material; titanium in titanium dioxide; and molybdenum in powellite.

The Meade Peak has been altered and naturally benefitted by postdepositional weathering (supergene enrichment). Unaltered phosphorite is hard, carbonaceous, calcareous to dolomitic, and lower in phosphate content than altered phosphorite, whereas the altered rock is partially consolidated, low in organic matter and carbonate minerals, and 3 to 10 percent higher in phosphate content (Hale, 1967). The weathered-unweathered interface in the rock is believed to be highly irregular and gradational.

**IDENTIFIED RESOURCES**

A total of 1,960 million short tons of identified phosphate resources with a weighted average of 24.7 percent \( \text{P}_2\text{O}_5 \) is within the Meade Peak Phosphatic Shale Member in the Stewart Flat quadrangle: 504 million short tons of...
resources with less than 300 feet of overburden, 395 million short tons of resources with 300 to 600 feet of overburden, and 1,060 million short tons of resources with 600 to 1,500 feet of overburden. Thickness and P₂O₅ data from 17 drill-hole and trench logs in the Stewart Flat quadrangle and the southern part of the adjacent Snowdrift Mountain quadrangle were used to calculate these resources. Resources are based on data from the drill holes and/or trenches situated along the same structural feature.

REFERENCES


¹ Resources calculated to three significant figures for phosphate rock containing 16 or more percent P₂O₅.