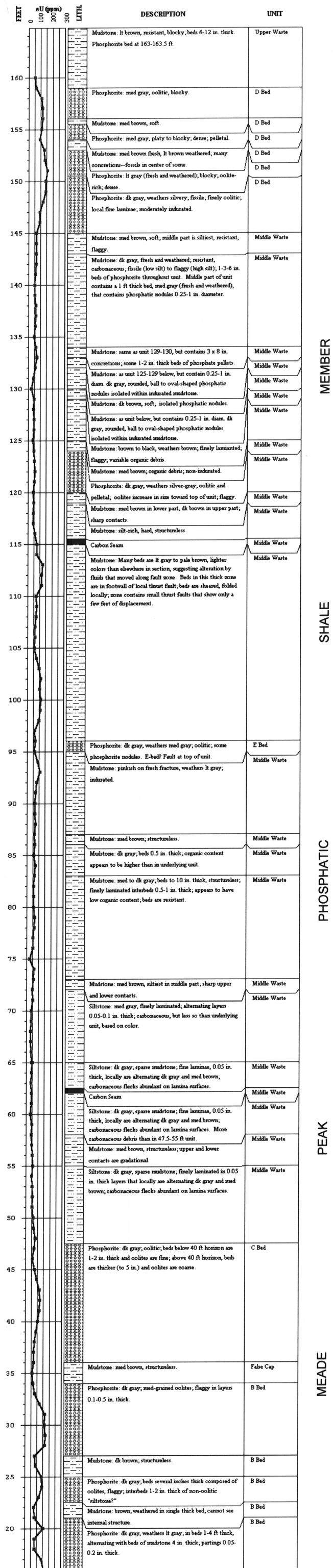
U.S. DEPARTMENT OF INTERIOR
U.S. GEOLOGICAL SURVEY

OPEN-FILE REPORT 99-20-A

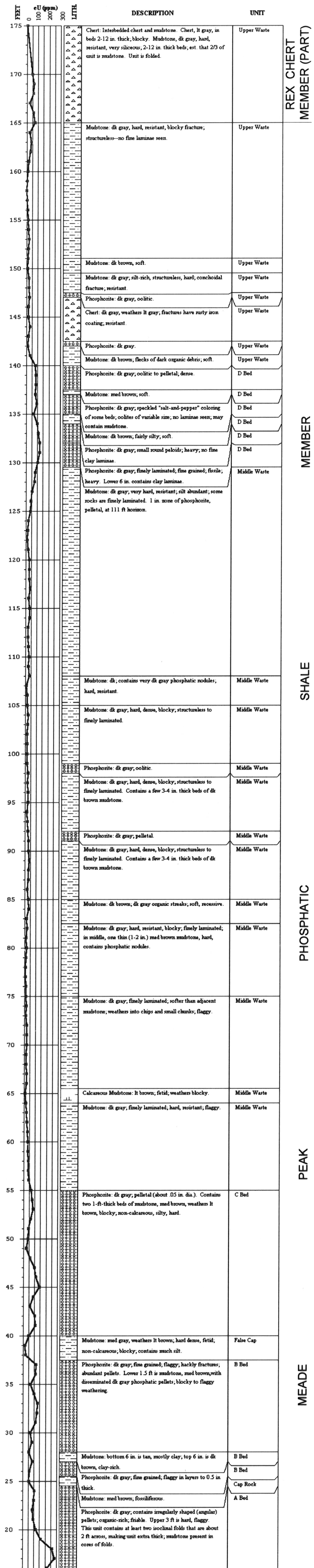
WESTERN PHOSPHATE PROJECT — Page 1 of 1

Section: wpsA **Date Measured:** 6/11/98 **Sec-Twn-Ra:** Sec. 22, T. 6 S., R. 43 E.
Formation: Phosphoria **Lat:** 42 deg., 53.04' N.
Member: Meade Peak **Long:** 111 deg., 24.66' W.
Measured By: Tysdal, Johnson, Herring, Desborough **Quadrangle:** Wayan West
Notes: **Mine:** Enoch Valley



WESTERN PHOSPHATE PROJECT — Page 1 of 1

Section: wpsB **Date Measured:** 6/12/98 **Sec-Twn-Ra:** Sec. 22, T. 6 S., R. 43 E.
Formation: Phosphoria **Lat:** 42 deg., 52.97' N.
Member: Meade Peak **Long:** 111 deg., 24.68' W.
Measured By: Tysdal, Johnson, Herring, Desborough **Quadrangle:** Wayan West
Notes: **Mine:** Enoch Valley



INTRODUCTION

The U.S. Geological Survey (USGS) has studied the Permian Phosphoria Formation in southeastern Idaho and the entire Western U.S. Phosphate Field throughout much of the twentieth century. In response to a request by the U.S. Bureau of Land Management (BLM), a new series of resource and geoenvironmental studies was initiated by the USGS in 1998. Present studies consist of (1) integrated, multidisciplinary research directed toward resource and reserve estimations of phosphate in selected 7.5-minute quadrangles; (2) elemental residence, mineralogical and petrochemical characteristics; (3) mobilization and reaction pathways, transport, and fate of potentially toxic elements associated with the occurrence, development, and societal use of phosphate; (4) geophysical signatures; and (5) improving the understanding of depositional origin. To carry out these studies, the USGS has formed cooperative research relationships with two Federal agencies, BLM and the U.S. Forest Service (USFS), which are responsible for land management and resource conservation on public lands; and with five private companies currently leasing or developing phosphate resources in southeastern Idaho. The companies are Agrium U.S. Inc. (Rasmussen Ridge mine), FMC Corporation (Dry Valley mine), Rhodia Inc. (Wooley Valley mine—inactive), J.R. Simplot Company (Smoky Canyon mine), and Solutia Inc. (Enoch Valley mine). Because raw data acquired during the project will require time to interpret, the data are released in open-file reports for prompt availability to other workers. The open-file reports associated with this series of resource and geoenvironmental studies are submitted to each of the Federal and industry cooperators for technical review; however, the USGS is solely responsible for the data contained in the reports.

MEASURED SECTIONS

Stratigraphic sections of the Phosphoria Formation were measured and sampled by the USGS at several places in southeastern Idaho. The sections, lacking interpretation and explanatory notes, are published as preliminary reports as they are assembled. No thin section, X-ray, or analytical technique other than gamma spectrometry has been used to augment the field descriptions of the rock units in this report. The descriptions are accompanied by a computer-generated lithologic log. Informal bed designation names introduced by Hale (1967, p. 152), and used generally throughout southeastern Idaho, are shown in the unit column. Informal bed names used only within a specific mine are not presented here. The units within the measured sections were sampled for geochemical and petrological analysis and also were evaluated with a variety of geophysical techniques. English units of measurement are used throughout this report to facilitate direct correspondence with units in the extensive historical literature on the Phosphoria and with current industry usage.

The Phosphoria Formation in the vicinity of the measured sections consists of three members, which in ascending order are the Meade Peak Phosphatic Shale, Rex Chert, and the informally named cherty shale (McKelvey and others, 1959; Oberlindacher, 1990). The measured sections of this report focus on the Meade Peak Phosphatic Shale Member. The Meade Peak unconformably overlies the Grandeur Tongue of the Permian Park City Formation, and the cherty shale member is overlain by the Triassic Dinwoody Formation. Both sections were measured on surfaces exposed by mining equipment. Section wpsA (western phosphate section A) was measured along a nearly vertical outcrop face; section wpsB was measured along a horizontal surface. Section wpsA is located about 500 ft north of section wpsB, is about 100 ft higher in elevation, and is much closer to the land surface that existed just prior to mining. Measuring a pair of sections close together, but at different depths below this land surface, permits evaluation of important effects of weathering on rock geochemistry. Measurements record true thickness. Adjustments were made for dip of beds at the time of measurement. The two sections are of similar thickness, as expected; however, bed A in section wpsB is considerably thicker than in section wpsA due to tight folding of the bed, as noted in the lithologic log.

EQUIVALENT URANIUM (eU)

Each of the two sections is accompanied by a profile of the equivalent uranium (eU) concentrations, measured using a GAD-6 gamma spectrometer. This instrument measures gross gamma flux (including cosmic rays) and provides a quantitative measure of K, U, and Th. Determination of the abundance of these three elements occurs via detection and counting of a specific radionuclide surrogate for each element; each radionuclide has a distinctive energy peak in the total gamma ray spectrum. Total abundance of each of the three elements assumes equilibrium between the measured nuclide and all collective isotopes for each individual element. The spectrometer integrates detection over a 2π geometry of approximately ½ m^3, with proportionally higher detection weighting given to those gamma rays that are emitted closest to the detector.

Previous studies of the Phosphoria Formation have shown that the eU varies in direct proportion to total uranium and that total uranium varies in almost direct proportion to the phosphate content (McKelvey, 1956). For example, in an exhaustive study of nearly 1,000 phosphatic rocks from the Phosphoria of southwestern Montana, U and eU differed by no more than 0.002 percent in a subset, and for the entire set the general ratio between eU and P_2O_5 was 0.3 x 10^{-3} (Swanson, 1970), with approximately 85 percent of the values contained within the range of 0.17 x 10^{-3} to 1 x 10^{-3}. Scatter in the U to P_2O_5 relationship results from syndepositional effects and (or) from post-depositional alteration, especially weathering. For the phosphatic rocks of the Phosphoria Formation, total gamma counts are dominated by decay of uranium and its various daughter products. The uranium is mostly located in the phosphate mineral lattice as a substitute for Ca; location of the decay (daughter) products is uncertain. K_2O in the phosphorite is generally <1 percent, and Th concentrations are generally <25 ppm (parts per million) (Altschuler and others, 1980; Swanson, 1970; Herring, unpub. data). Concentrations of eU are given in parts per million and are approximately equivalent to the total uranium concentration, also in ppm.

ACKNOWLEDGMENTS

The sections were measured within the Enoch Valley mine, operated by Solutia Inc. We thank Solutia for providing access and we thank company personnel who freely discussed the geology of the area.

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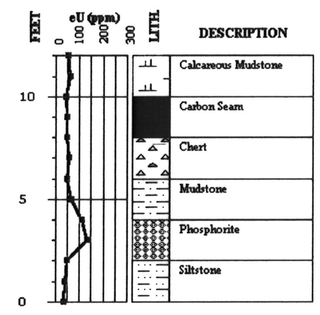
EXPLANATION



INDEX MAP SHOWING LOCATION OF MEASURED SECTIONS

Prepared in Cooperation With:
U.S. Bureau of Land Management
U.S. Forest Service
Agrium U.S. Inc.
FMC Corporation
J.R. Simplot Company
Rhodia Inc.
Solutia Inc.

STRATIGRAPHIC SECTIONS AND EQUIVALENT URANIUM (eU), MEADE PEAK PHOSPHATIC SHALE MEMBER OF PERMIAN PHOSPHORIA FORMATION CENTRAL PART OF RASMUSSEN RIDGE, CARIBOU COUNTY, IDAHO

BY

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1999