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RECONNA SSANCE FOR URANIUM IN THE
CUZCO-AYAVIR REG ON, SOUTHERN PERU

By
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October 1957

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Washington, D. C.

and

Junta de Control de Energia Atomica
Lima, Peru

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DIVISION OF RAW MATERIALS
IN COOPERATION WITH THE
JUNTA DE CONTROL DE ENERGIA ATOMICA DEL PERU

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RECONNAISSANCE FOR URANIUM IN THE
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ABSTRACT

Geologic and radiometric investigations of the Cuzco-Ayaviri region in southern Peru were made in a search for geologic features or structures which might be favorable for the occurrence of uranium.

Outcrops consist of Lower Paleozoic sedimentary and metamorphic rocks; Permian to Carboniferous volcanic flows, tuffs, breccia and agglomerate, together with sedimentary rocks; and Cretaceous and sedimentary rocks. Cretaceous to Tertiary igneous rocks are acidic intrusives and extrusive rhyolite, dacite and trachyte. Tertiary to Quaternary volcanic tuffs, breccias and agglomerates are also present.

Although no anomalous radioactivity was observed, favorable geologic features for the occurrence of uranium were noted at two localities.

INTRODUCTION

This reconnaissance project was undertaken to determine the favorability for uranium mineralization of the area between Anta (just west of Cuzco) and Ayaviri in southern Peru. No radioactivity anomalies had been measured in this area on previous visits, but the generalized geologic map of Peru (Bellido et al., 1956) and information in the literature indicated that some of the rock formations might possess favorable structural or lithological characteristics for the occurrence of uranium.

The area shown in figure 1 covers approximately 600 square kilometers in southern Peru; 85 percent lies in the Department of Cuzco and 15 percent in the Department of Puno.

The work was done in October 1957. Scintillation and Geiger counters were used to detect surface radioactivity and to determine variations in radioactivity between the different rock types. Mapping of the rocks and their contacts (fig. 2) was done on a more detailed scale than that of the generalized geologic map of Peru.

Geography

Location and accessibility

The area examined (fig. 1) extends southeast from latitude $13^{\circ} 28' S.$, longitude $72^{\circ} 10' W.$ to latitude $14^{\circ} 52' S.$, longitude $70^{\circ} 37' W.$ The section from Anta to Cuzco is on the Abancay-Cuzco highway, and the portion

Figure 2

GENERALIZED GEOLOGIC MAP OF THE CUSCO-AYAVIRI AREA

from Cuzco to Ayaviri is on the Cuzco-Puno highway. These dirt and gravel roads are generally maintained in good condition although travel is difficult during the rainy season. In addition, pack trails and footpaths provide access to the area.

Topography, vegetation and climate

This area in the Cordillera Oriental of southern Peru shows considerable variation in elevation, with altitudes ranging from 3000 to over 6500 meters above sea level. The relief ranged from medium to high, and the mountains usually have steep slopes with youthful, V-shaped valleys. The principal drainage is from southeast to northwest by the Urabamba, Vilcanota and Paucartambo rivers, all tributaries of the Amazon.

The only two distinct seasons in the high Andes are the wet period from November to April and the dry period from May to October. During the wet season rain falls almost daily, making some roads and trails virtually impassable. Daily and nightly temperatures do not vary markedly during the wet season, but there are warm, sunny days and cold, clear nights in the dry season.

The higher peaks have no vegetation, but elsewhere grass is the chief vegetation, with some trees (mostly eucalyptus), shrubs and cacti also present. Nowhere is vegetation as thick and abundant as it is in the highlands of the Amazon.

At present an adequate supply of water is available in the Cusco area, but the Puno sector is suffering the effects of a prolonged drought. The principal water sources are the Urabamba, Vilcanota, Paucartambo and Huatana rivers. A well-developed canal system provides irrigation for crops.

GEOLOGY

This area contains some of the oldest as well as some of the youngest rocks in Peru. The eastern section comprises a large expanse of lower Paleozoic rocks, while the western section consists mainly of Permian to Carboniferous rocks, Tertiary continental sediments, and Cretaceous to Quaternary intrusive and extrusive rocks. Small areas of Cretaceous sediments also are exposed (fig. 2).

Rock exposures are fairly common although some sections are covered by a soil mantle. Good exposures are visible in road and railroad cuts, in stream beds, and in cliffs and precipices.

Lower Paleozoic rocks

The lower Paleozoic rocks comprise quartzite, shale, sandstone, conglomerate, phyllite, slate, schist and gneiss. The quartzite is massive to thick bedded, its colors on a fresh surface varying from light gray to pink or pale red. Some of the quartzite is well indurated and highly

siliceous; other parts are calcareous. Well-developed joints and fractures visible at some places are generally tight, shallow and unmineralized.

A fissile shale, gray to green and black, weathering to buff and brown, is associated with the quartzite. It is usually thin bedded and compact, but some massive outcrops occur. Possibly some of the black shale contains carbonaceous material though none was seen. Fractures are local and shallow.

The sandstone varies from gray to pink in color and from very fine to medium grained. Some of the sandstone is arkosic. Cementation is usually good, calcareous in some instances and siliceous in others. Fractures are common, but usually are tight and shallow. A little aragonite occurs in small vugs in the sandstone.

Exposures of conglomerate are comparatively scarce. Cementation of these rocks is usually good and the fragment size varies greatly. The conglomerate is not thick nor is it extensive.

Phyllite is generally gray to green in thin friable beds which are fractured and usually intercalated with schist. Outcrops are scarce and limited in extent.

Outcrops of slate are rare. Those observed are dark gray and fissile, folded and faulted. The slate is usually associated with shale, schist and quartzite.

Occurrences of schist are limited to a few outcrops. This rock is principally dark gray to black, and its schistosity is well defined. Some exposures are fractured and folded, and some fractures contain quartz. The micaceous schist, which weathers buff to brown, is associated with phyllite and slate.

There are very few outcrops of gneiss. It weathers gray to buff, and appears gray on a fresh surface. Banding is a prominent feature; the associated rocks are phyllite, schist, and quartzite. Some schistosity appears, and fracturing occurs along the planes of schistosity.

Permian to Carboniferous rocks

These rocks include volcanic flows, stratified and unstratified tuffs, breccia and agglomerate, red and gray shale, limestone and sandstone.

Volcanic flows are principally dark gray to greenish andesite, pink to pale-red rhyolite, and gray dacite. These flow rocks are mostly massive, occasionally showing slight stratification. Some local fracturing has occurred, but the fractures are shallow and tight.

Both stratified and unstratified tuffs are found, the latter more commonly. The stratified tuff is generally white to light gray, well cemented and compact, and contains relatively few fractures. The unstratified tuff may be poorly consolidated or well compacted; it is gray, pink, red, or purple. Some of the unconsolidated tuff is crumbly and powdery, and appears to have undergone no cementation.

Breccia and agglomerate usually are well compacted and consolidated, and of pink to red color. Their porosity and permeability are low, and fractures are common. The size of fragment, especially in the agglomerate, varies greatly.

Red and gray shales occur intercalated with sandstone and gray limestone. Though much of the shale is massive and compact, some is thin bedded and fissile. Fracturing is uncommon and the contacts seem conformable.

A small amount of medium-bedded limestone is intercalated with shale and sandstone. The limestone varies from gray to red, and some dolomitization and silicification are apparent; iron oxide is prevalent.

Sandstones vary from saccharoidal to medium grained in texture and from white to red in color. Some sandstones are quartzitic, others tuffaceous or calcareous. Cementation is generally good. At one locality the rock is highly folded and fractured; it contains shaly partings and shows cross-bedding.

Cretaceous rocks

Regionally these rocks lie discordantly on the older formations. The Lower Cretaceous consists principally of sandstone and shale, with some intercalated limestone. The sandstone is pink to pale red, fine grained, thin bedded or massive, and calcareous or siliceous; cementation is good and fractures are rare. The shale is pink to red, thin bedded and fissile, and calcareous in places. The limestone is gray, massive to thick bedded, and compact; it contains numerous shallow, tight fractures perpendicular to the bedding.

The Upper Cretaceous is represented by gray to black, compact, massive limestone which alters to buff, brown, and black. No fractures are visible.

Tertiary sedimentary rocks

These consist of sandstones, fine to medium grained, gray to red, thin bedded to massive, arkosic to tuffaceous, with some shaly partings and intercalated maroon and brown shales and arenaceous shales. There are small, tight folds in places, and alteration is absent. Small conglomerate stringers occur at a few places. The quartz and feldspar grains are subangular to subrounded and are well cemented. Porosity and permeability are relatively low, but some small shallow fractures are visible. Iron oxide is abundant.

Cretaceous to Tertiary igneous rocks

Igneous rocks of the Cretaceous and Tertiary periods are both intrusive and extrusive. The acidic intrusives contain quartz, orthoclase and plagioclase feldspars, and a small percentage of ferromagnesian minerals as identified by hand lens. Several different intrusive rocks occur, each

varying slightly from the others in composition and appearance. Their colors vary from gray to pink and they weather gray to buff. A well-developed system of joints is seen at a few places.

The extrusive rocks are principally rhyolite, dacite and trachyte, which weather pink to buff. No good joint systems are visible, and there are no altered zones.

Tertiary to Quaternary igneous rocks

These rocks are volcanic tuffs, breccias and agglomerates. The tuffs vary widely in color from white to gray, pink, red and purple. Their cementation also varies from well consolidated and compact to very loose. There is much alteration and a large quantity of gypsum is present. The breccias and agglomerates are generally well cemented and compact, and show little alteration. They usually are red or brown.

Structure

Although no favorable major geologic structures exist in the Cuzco-Ayaviri area, there are some minor folds, faults and flexures and a few local homoclines and monoclines that may warrant some additional study. The depositional discordancies that occur do not seem to be favorable for the occurrence of uranium.

RESULTS OF RADIOMETRIC RECONNAISSANCE

No anomalous radioactivity was observed in our reconnaissance of the area. The average background ranged from 0.01 to 0.05 mr/hr on the scintillation counters, with the lowest background count recorded over sandstone and quartzite. The background increased over certain types of volcanic rock such as tuff, breccia, agglomerate and trachyte, and also over some black, slightly carbonaceous shale.

Two localities may warrant further attention. At one along the road between Ayaviri and Umachiri in the Department of Puno are continental Tertiary sandstones containing much iron oxide. The sandstones are pink to red and arkosic, with the medium grains being subrounded and well consolidated in most places and loosely consolidated and intercalated with sandy shale in other places. Some concretions are evident along with small, irregular, lens-shaped channels of coarse-grained conglomerate and breccia. The sandstone is partly massive and partly bedded. It lies unconformably on a light- to medium-gray, compact, massive limestone in contact with a large section of consolidated breccia. The contact has a steep angle and probably is an angular unconformity. The sandstone dips 21 to 23 degrees.

The second locality is in the valley of the Chosicani Hacienda about 10 kilometers north of Chuquibambilla on the Sicuani-Ayaviri road, Department of Puno. The continental Tertiary red sandstone exposed is medium grained and in beds of medium thickness. The sandstone is well cemented in places

and loosely consolidated in others; its dip of 7 degrees appears to be homoclinal. Siliceous, white to gray, compact limestone underlies the sandstone.

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Bellido B., E., Narvaez L., S. and Simons, F. S., 1956, Mapa geológico del Peru, 1:2,000,000: Soc. Geol. del Peru.