THE ELKHEAD MOUNTAINS VOLCANIC FIELD, NORTHWESTERN COLORADO

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INTRODUCTION

The Elkhead Mountains are the erosional remnants of an isolated Tertiary volcanic field located in Moffat and Routt Counties of northwestern Colorado. The mountains are situated a few miles south of the Wyoming-Colorado state line and east of Colorado State Highway 13 along the drainage divide between the Yampa and the Little Snake Rivers. The boundaries of the Elkhead Mountains volcanic field extend considerably beyond the mountains, volcanic flows and/or dikes being found as far north as Battle Mountain, Wyoming and as far south as Cedar Mountain near Craig, Colorado. The westernmost volcanics occur as Fortification dike which extends several miles west of the highway between Baggs, Wyoming, and Craig, Colorado. The south and east boundaries of the volcanic field are rather ill-defined in that the volcanics from the Elkhead Mountains merge with those that extend north from the White River Plateau and those that extend north and west from the Rabbit Ears and Yampa regions. Hahns Peak is generally considered as being somewhere near the eastern end of the volcanic field.

CHRONOLOGY OF INVESTIGATIONS

With the exception of the areas in the immediate vicinities of Hahns Peak and Fortification dike, the Elkhead Mountains have received little geologic investigation since the time of the early regional surveys. During the 1870's the range of mountains was visited by members of the Powell and Hayden surveys, but very little is written concerning the geology in their subsequent reports. In contrast to these two surveys, the geologists participating in the exploration of the Fortieth Parallel (King Survey) studied the Elkhead Mountains in considerable detail. The reports of Emmons (1877), King (1878), and Zirkel (1876) all contain most of the published information treating with the geology of the Elkhead Mountains and the volcanic field found therein.

White (1899, plate XXXIV) included in his discussion of the geology of northwestern Colorado, a geologic map which depicts the Elkhead Mountains and the general distribution of the eruptive rocks. It is probable, however, that the information was obtained from the publications of the King Survey.

The discovery of placer gold at the base of Hahns Peak in 1864 led to considerable interest in the immediate area by the mining industry. At a result of this interest, a number of brief geologic accounts dealing primarily with the Hahns Peak gold field were published. Among these are the reports by Draper (1897), Gale (1905), Lakes (1909), and George and Crawford (1909). The latter describes the geology of the gold field in considerable detail. Production statistics and/or estimates of the mineral resources of the Hahns Peak district are included in reports by Lee (1901), Parsons and Liddell (1903), White (1906), Worcester (1919), Henderson (1926), and Vanderwilt (1947). The most comprehensive information concerning the geology of the Hahns Peak area is contained in theses by Barnwell (1955) and Hunter (1955).

The publications of the King Survey and those concerned with the geology of the Hahns Peak area constitute the major portion of the information on the geology of the Elkhead Mountains. Some minor occurrences of high grade coal, however, are briefly discussed in a report by Chisolm (1887). Fortification dike has been studied in detail, perhaps, because of the unusual rock types, the impressive erosional form, and the proximity to an interstate highway. Ross (1926) discusses the petrography of several samples collected from the dike along with several flow rocks found near the town of Craig.

In addition to the published material, considerable information concerning the geology of the Elkhead Mountains has been obtained in the past few years by geologists working within the oil industry. Unfortunately, much of this information is contained in company files and is not available for publication.

DESCRIPTIVE GEOLOGY

The Elkhead Mountains are contained in an area of approximately 18 townships between the exterior lines of Townships 9 and 11 North, Ranges 85 and 90 West. The outer boundaries of the Elkhead Mountains volcanic field extend beyond the mountain range and are contained between the exterior lines of Townships 6 and 13 North, Ranges 85 and 91 West. There is no adequate published geologic map of the Elkhead Mountains and the volcanic field. The map which best depicts the geography of the area is the U. S. Depart-

ment of Agriculture Forest Service map of Routt National Forest.

The volcanic field is located regionally on the axis and the south flank of a large east-west trending structural arch which plunges westward into the basin from the west flank of the Sierra Madre Mountains. The axis of the arch coincides fairly closely with the Colorado-Wyoming state line.

The Elkhead Mountains are composed of the erosional remnants of the volcanics and the associated Tertiary sediments. The large flat-topped mountains among which are Mt. Welba and Mt. Oliphant consist of thick flows of lava overlying the Browns Park and North Park (?) formations. The steep-sided conical-shaped mountains similar to Hahns Peak and Bears Ears are the remnants of large volcanic stocks or plugs.

The Browns Park formation overlies with considerable angular unconformity all formations from the Mancos shale on the east end of the mountains in the vicinity of Hahns Peak to the Wasatch formation on the west end in the vicinity of Mt. Welba. The basal Browns Park conglomerate is well exposed at a number of localities throughout the volcanic field. The thickness of the Browns Park formation in the vicinity of Hahns Peak is estimated by Barnwell (1955, p. 32) as being approximately 1,200 feet.

On Sand Point, northwest of Mt. Welba, are excellent exposures of the transition zone between the Browns Park formation and the overlying volcanics. Initial volcanism can be detected by the appearance of small fragments of volcanic debris imbedded in a typical Browns Park sandy matrix. The fragments become larger higher in the section, and at the top of Sand Point the sediments consist of a volcanic breccia with boulders a foot or more in diameter. It is probable that the several hundred feet of volcanically derived sediments immediately beneath the high lava flows on Mt. Welba are the local equivalent of the North Park formation

The masking effect of the volcanics and the Tertiary sediments makes it impossible to resolve the structure of the Paleozoic and Mesozoic rocks beneath the Elkhead Mountains except by geophysical methods. Structural control by some of the intrusives, however, is very much in evidence. A large number of dikes throughout the volcanic field trend approximately N. 60° W. A swarm of dikes trending in this direction is particularly apparent throughout Township 10 North, Ranges 86 and 87 West. Since a considerable number of local post-volcanism normal faults also trend in this direction, it is probable that a well developed fracture system exists in the basement rocks.

PETROGRAPHY

The petrographic descriptions of the Elkhead Mou tains volcanics are confined principally to five repor The most comprehensive is that by Zirkel (1876) which a number of rock samples collected from loca ties throughout the volcanic field are described. A fe of the descriptions include chemical analyses. Ro (1926), in addition to his descriptions of the ro samples collected from the Fortification dike, include in his report descriptions of an analcite basalt collecte from Breeze Mountain four and one-half miles sout east of Craig and an olivine basalt collected from Bu Peak six miles southeast of Craig. The reports George and Crawford (1909), Barnwell (1955), ar Hunter (1955) describe several samples of rhyoli porphyry and olivine basalt from the Hahns Peak are A chemical analysis of a nepheline tephrite from t Elkhead Mountains is reported by Cross (1904, p. 187

Emmons (1877, pp. 167-168) pointed out the u usual nature of the volcanic rock suite in the Elkhea Mountains. He wrote:

> From a mineralogical point of view, the eruptive roc of the region form a remarkably interesting and peculi group, being characteristically different from any of t wide-spread groups of volcanic rocks, which cover so lar an area in the western portion of the region embrac within our explorations. They consist mainly of quart ferous trachytes and nepheline basalts . . . These trachyt besides the normal constituents, sanidine, hornblende, a mica, contain also a relatively large proportion of augi and in some cases a considerable amount of olivine . The basalts of the region are no less remarkable than t trachytes, being the only representatives of the group nepheline-basalts found within the limits of our explo tion.

To the student of petrography who believes in orderly, simple classification of volcanic rocks, the ro suite in the Elkhead Mountains constitutes somethi very close to a petrographic nightmare. Zirkel (187 p. 160) describes a rock from Whitehead Peak whi contains both quartz and olivine. It was the first obse vation of this mineral combination. He describes nepheline-bearing trachyte from the mouth of Slate Fork which consists of phenocrysts of yellow-brow mica in a groundmass of sanidine and nepheline. T rock contains no hornblende or quartz, but exhibits we developed crystals of augite and olivine. The trachy from Steves Ridge is said to resemble closely t Drachenfels trachyte from the Rhine River area.

The basalts from the Elkhead Mountains belon with few exceptions, to the group of nepheline basal containing little or no feldspar, but in general conside able olivine with lesser amounts of augite and ma netite. Occasionally biotite and some triclinic feldsp is found (Emmons, p. 176). The writer has examin a number of thin sections of the volcanics and wh

as been described as nepheline would now be termed analcite.

The rock types found in the Fortification dike are no less unusual than the others among the suite. Ross (1926) describes the main rock type as a finely-crystalline soda-verite, and compares the rock with a verite described by de Yorza from Fortuna, Murcia, Spain, and one described by Osann from Cabo de Gato, Almeria, Spain. The dike rock consists essentially of phenocrysts of biotite, augite, and olivine in a soda-sanidine groundmass. Other rocks found within the dike are described as analcite syenites and soda-syenites.

Emmons (1877, p. 173) believes that the acidic intrusive forming Hantz Peak (Hahns Peak) is the only occurrence of rhyolite in the region. If this is true the stock forming Hahns Peak may be more closely associated with the volcanics in the vicinity of Steamboat Springs than with those of the Elkhead Mountains volcanic field.

AGE OF THE VOLCANISM

The volcanism in the Elkhead Mountains is either late Browns Park and/or North Park in age. A provincial age determination is impossible until Tertiary stratigraphers can agree on the provincial ages of the two formations. For many years the Browns Park formation has been considered as being Upper Miocene and the North Park as definitely Pliocene. A number of vertebrate paleontologists, however, have questioned these age determinations. Additional faunal collections from areas adjacent to the type areas have prompted a re-evaluation of the faunal collections upon which the formational age determinations are based.

A suggestion is now before the Committee on the Continental Cenozoic of the Society of Vertebrate Paleontologists to consider the Browns Park formation as Middle Miocene (Hemingfordian), and, perhaps, partly Lower Miocene (Arikareean) in age. The North Park formation is now known definitely to be at least partly Upper Miocene (Barstovian) in age (McGrew, 1955). If these modifications are accepted the volcanism in the Elkhead Mountains must be considered as occurring between Middle Miocene and Lower Pliocene time.

ECONOMIC GEOLOGY

The Hahns Peak mining district has been an intermittent producer of gold, silver, copper, and lead since 1866. The principal product until approximately 1895 was placer gold. Since that time attempts have been made to produce lode deposits of gold, silver, lead, copper, zinc, and molybdenum which are found within the acidic intrusives and the adjacent sedimentary and pre-Cambrian rocks. Most ventures failed to recover their investments. Mining activity is still in progress but on a very limited scale. The total value of all mineral production from the district through 1954 has been estimated as between $400,000 and $500,000 (Barnwell, 1955, pp. 74-84).

In addition to the Hahns Peak area, placer gold has been observed at a number of localities throughout the Elkhead Mountains. Several gold-bearing placer deposits are indicated on the original U. S. General Land Office survey plats.

Recently, the Elkhead Mountains have received considerable attention by the oil industry. Only future drilling can evaluate the oil and gas potential of the Paleozoic and Mesozoic sediments buried beneath the volcanic field.

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