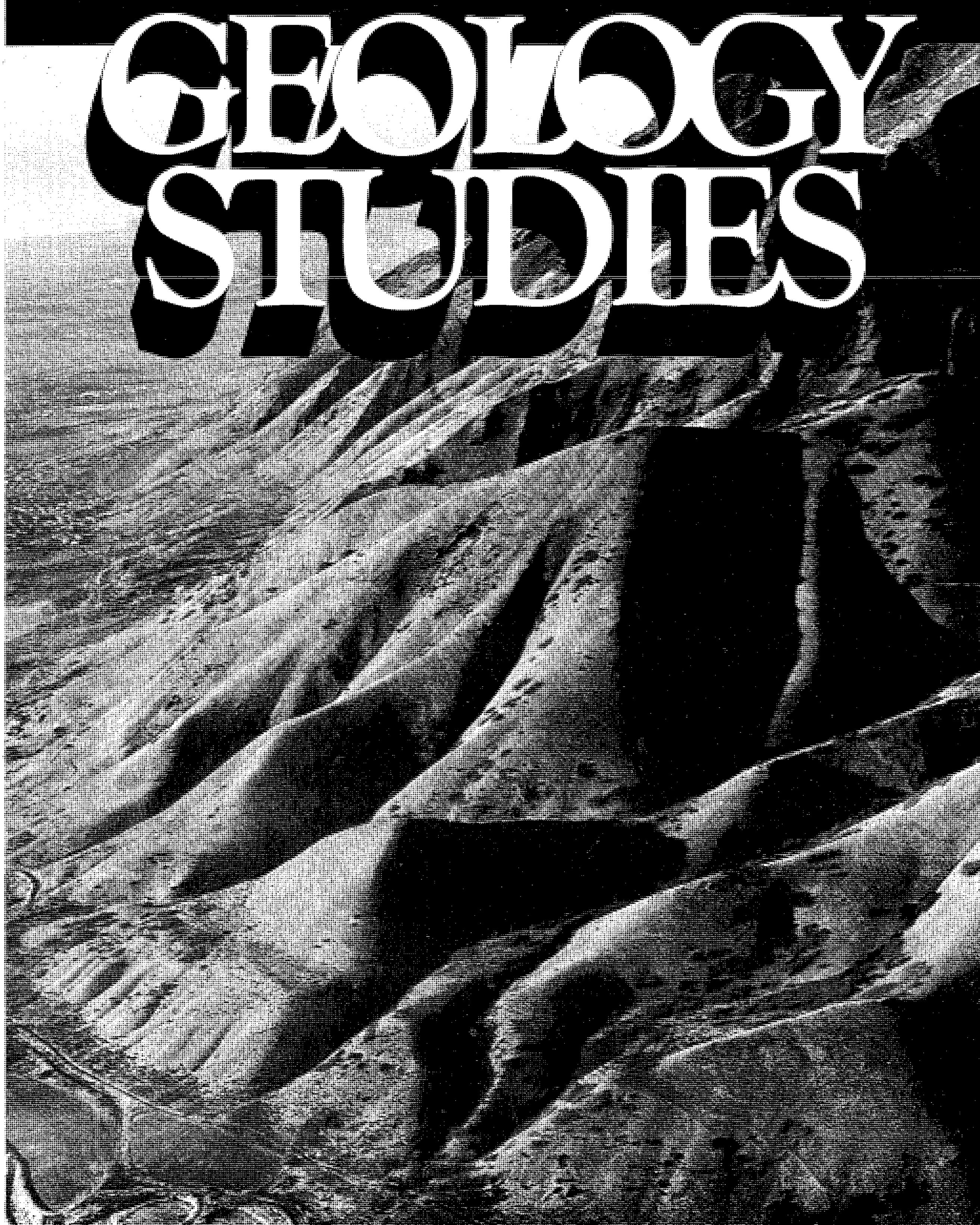
BRIGHAM YOUNG UNIVERSITY

GEOLOGY STUDIES



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Cover: Compound faceted spurs along the Wasatch Mountains indicate alternating periods of fault displacement and tectonic stability.

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CONTENTS

Stratigraphic Relations of the Escalante Desert Formation near Lund, Utah

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ABSTRACT.—The Escalante Desert Formation (new name) is a thick series of crystal-poor, lithic-bearing ash-flow tuffs underlying the Needles Range Formation. Included in the formation are beds of volcaniclastic rocks with chemical compositions similar to the ash flows that they separate. The ash flows of the lower member of the type locality have fewer crystals than do younger ash flows of the formation and are further characterized by the presence of sedimentary xenoliths. The middle and upper members are alike in having amphibole-bearing vitrophyres and moderate amounts of calcic andesine. Lithic fragments are more abundant near the base of each of the three members.

Overlying the Escalante, the Wah Wah Springs and Lund Members of the Needles Range Formation are separated from each other by traces of crystal-poor welded tuff, duplicating relationships observed at Ryan Spring in the Needle Range. There, ash flows with compositions similar to parts of the Escalante underlie the Lund but overlie the Wah Wah or its intracaldera equivalent. Ash flows younger than the Wah Wah are not included in the Escalante Desert Formation.

INTRODUCTION

The rocks described here occur along the western margin of the Escalante Desert, from Blue Mountain to Lund, and lie entirely within the Lund Quadrangle, 7.5 Minute Series. Exposures are more nearly complete in the middle of the area, where volcanic rocks overlie an eroded terrain of Mesozoic sandstones and Paleozoic carbonate rocks which were involved in prevolcanic regional thrusting (Miller 1966). Beneath the volcanic section, mantling the sandstones and carbonate, is a conglomerate composed of cobbles and boulders mainly quartzite with some carbonate. A volcanic conglomerate appears above the sedimentary conglomerate and contains some of the same sedimentary clasts among the predominantly igneous constituents.

Volcanic rocks younger than these two conglomerates dominate the stratigraphic section in the area. In order of decreasing age they are: tuff of Frisco, Escalante Desert Formation (new name), andesite and rhyolite flows, Wah Wah Springs Tuff Member of the Needles Range Formation, a complex of flows and welded tuff, Lund Tuff Member of the Needles Range Formation, Isom Formation, and post-Isom tuffs. This volcanic section is unconformably overlain by Tertiary sediments, basalt(?), and alluvium.

Appreciation is extended to staff and students of the University of Missouri-Rolla geology field camp who contributed to the collection of data, and to M. G. Best for critically reading the manuscript.

VOLCANIC STRATIGRAPHY AND LITHOLOGY

The oldest volcanic unit is a conglomerate composed of mainly igneous clasts of cobble to boulder sizes in a fine-grained matrix of quartz latite composition. It may be as much as 60 m thick but is nowhere exposed in its entirety. Either the base is covered by alluvium or the top is involved in faulting.

The next unit, the oldest ash flow in the study area, is informally called the tuff of Frisco, from the occurrence of similar tuff 3.2 km southwest of the site of Frisco in the San Francisco Mountains. This tuff is absent from the section in the extreme south, but appears elsewhere in thickness of a few hundred meters (fig. 1). The lithology is characterized by prominent quartz, often larger than 3 mm, and a peculiar biotite with basal surfaces that are warped or wrinkled. Scarce lithic fragments are occasionally large (10 cm). Sites of pumice fragments are often lens-shaped voids.

The tuff of Frisco, together with possible regional equivalents, needs more study before firm correlations are possible. Differences in chemistry and mineralogy among Frisco samples imply lateral or vertical variations in a single unit or suggest the presence of several units of similar aspect. The Sawtooth Peak Formation of Conrad (1969) is a possible time equivalent of the tuff of Frisco in that both have been deposited directly on Paleozoic basement at their naming localities. However, the Sawtooth Peak Formation seems to have too much quartz and sanidine, in my scarce data, to allow correlation. The Frisco has about 10% quartz, trace of sanidine, 17% plagioclase, 3% biotite, trace of amphibole, 0.5% opaques, and 69% groundmass (average of six samples from Blue Mountain and Frisco localities).

The Escalante Desert Formation (new name) overlies either the volcanic conglomerate or the tuff of Frisco, depending on whether the Frisco is present in the section. The Escalante is a series of relatively crystal-poor ash-flow tuffs with some intercalated epiclastic and pyroclastic beds. The type section for the formation is the northeast flank of hill 6535 (Lund Quadrangle), section 6, T. 32 S, R. 14 W. It includes all lithologies from the first ash flow above the volcanic conglomerate to the base of the Wah Wah Springs Member of the Needles Range Formation. Included at its top is a bed of volcanic conglomerate.

For discussion purposes, the Escalante Desert Formation is informally subdivided by use of clastic beds, cooling units, and unusual mineral concentrations (table 1). The ash flows of the formation at the type locality are labeled A through F. Cooling units in the lower part of the formation are not well defined. Therefore, ash-flow beds A, B, and C, together with the two clastic beds, are grouped as the lower member. Beds D and E, with the clastic bed below D, compose the middle member. Bed F is placed with the overlying conglomerate into the upper member.

Ash flows of the lower member of the Escalante have a consistent mineral composition, different from the younger members. The presence of quartz, the more sodic plagioclase, low content of crystals, and prolific amounts of sedimentary rock fragments in the lithic population serve to distinguish that portion of the formation. The rock fragments, mainly quartzite, decrease in abundance upward in the member. The overall chemistry of the member corresponds with the composition of the visible components, and the highly acidic character agrees with the low crystal content (Roberts and Peterson 1961).

The single cooling unit of the middle member has more crystals than the lower member and is mineralogically zoned. Amphibole appears in and near the vitrophyre at the top of bed

D, and quartz and sanidine occur toward the top of bed E. Following the pattern emphasized in this member, quartz and amphibole have not been found together anywhere in the formation. Bed F of the upper member is much like bed D in its mineral content.

The clastic beds have chemical compositions similar to the ash flows with which they are grouped. The thickness of each clastic bed and the size of clasts increase upward in the formation. Between beds A and B, the volcanic sandstone is 6 cm thick with a maximum grain size of about 1 mm. This thinnest clastic bed shows repeated reverse grading and is persistent within the area. The other clastic beds of the type locality were not found elsewhere. Estimated thicknesses and largest clast sampled are: 0.3 m thick and 1.5 cm across, for the breccia between beds B and C; 3 m thick and 7.5 cm across, below D; and 21 m thick and 1.5 m across for the conglomerate above F. New clastics were found away from the sample traverse that could not be correlated with the sampled ones.

Within the mapped area, individual members of the Escalante lack persistency. The middle and upper members thin northward from the type locality, and a new basal member appears. The removal or nondeposition of the younger members near Marsden Spring is probably a local phenomenon associated with the lava flows at that horizon. The new basal unit is at least 9 m thick a few kilometers north of where it begins between the type section and Marsden Spring. It is a medium-gray volcanic rock, probably a welded tuff, containing a few lithics, but questionable pumice. The chemical composition of the basal unit is nearer to the middle and upper members than to the lower. At Marsden Spring the lower Escalante has a minimum thickness of 111 m and overlies the basal member. It has much larger lithic fragments (6 cm) than at the type section (7 mm).

Regionally, Escalante-like strata of pre-Needles age occur throughout the northern Needle Range and the southern Wah Wah Mountains (Campbell 1978), and near Indian Peak in the Needle Range (Rauch 1975). At these locations the Escalante-like tuff lies under the Cottonwood Wash Member of the Needles Range Formation, sometimes with an intervening conglomerate. The mere occurrence of a crystal-poor tuff of Escalante type below crystal-rich Needles tuff is insufficient evidence, however, for correlation with the Escalante Desert Formation. Each of the three widespread members of the Needles Range Formation (Best and others 1973) is known to rest somewhere on tuffs that could pass for Escalante. One of these Escalante-type tuffs, the tuff of Ryan Spring (see below), is younger than the Wah Wah Springs Member, and could not fit into the presently defined Escalante Desert Formation.

At Marsden Spring, two local flows, one of andesite, the other younger one of flow-banded rhyolite, occur above the lower Escalante. The two flows are coextensive and may have

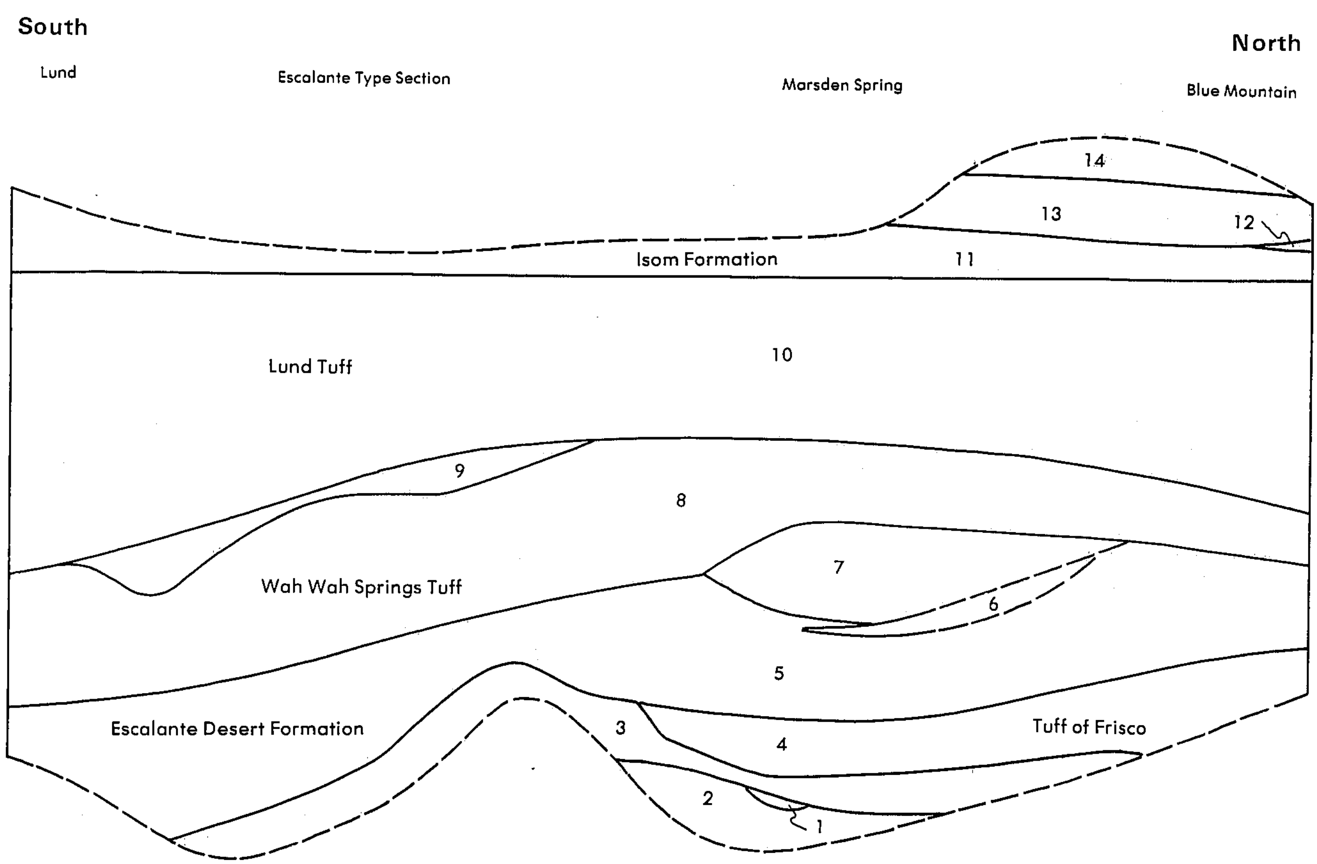

FIGURE 1.—Diagrammatic stratigraphic cross section from Lund to Blue Mountain: (1) Paleozoic carbonate rocks; (2) Mesozoic sandstone; (3) conglomerate; (4) tuff of Frisco; (5) Escalante Desert Formation; (6) andesite flow; (7) rhyolite flow; (8) Wah Wah Springs tuff; (9) flow and tuff complex; (10) Lund tuff; (11) Isom Formation; (12,13) post-Isom tuffs; (14) clastics and flows.

formed an obstacle hindering full development of the Escalante and younger ash flows.

The Needles Range Formation at Lund is represented by the Wah Wah Springs and Lund members. The two units have similarities in their average chemical and mineral content and in the patterns of their internal variations. They are easily distinguished from each other by the size of their quartz crystals and by the presence of sphene in the Lund tuff. The Lund has large quartz, at least one grain in every thin section equaling or exceeding 2.0 mm in maximum diameter. No sphene has been seen in the Wah Wah, and no quartz exceeds 2.0 mm.

Between the Lund and the Wah Wah is a 60-m zone of complex lithology involving lava flows (south) and volcanic sandstone and crystal-poor welded tuff (north). The sandstone occurs within, and has the chemical composition of, the welded tuff. The welded tuff may be the distal margin of the tuff of Ryan Spring (Rauch 1975), first studied by Conrad (1969), who included it in his Indian Peak Formation. Because the Ryan Spring relates to tuffs at Lund, data from its naming locality are included here. Many stratigraphic and nomenclature problems associated with the tuff of Ryan Spring stem from its similarity to the older Escalante Desert Formation. It is an Escalante-type tuff situated stratigraphically above the Wah Wah Springs Member of the Needles Range Formation (or its intracaldera equivalent) and below the Lund Member of the Needles Range Formation. It has not been included as a member of the Needles Range Formation because its low crystal content is not consistent with the defined members (Best and others 1973). It is not warranted to presently include it in the Escalante, since the Escalante and Ryan Spring have not been shown to be stratigraphically contiguous. The tuff of Ryan Spring at the naming locality (Rauch 1975, measured section I) in sections 35 and 36, T. 28 S, R. 19 W, is slightly more acidic than the middle and upper Escalante at Lund, as expressed by the chemical composition, anorthite content (An 37–44), and modal analysis (Rauch 1975). It is much less acidic than the lower Escalante. Routine microscopic work would likely fail to clearly distinguish between the Ryan Spring and Escalante tuffs.

The Isom Formation consisting of several thin ash-flow tuffs, with the typical lineated vesicles and including some flow-folded layers, is incompletely expressed over the Lund because of erosion, burial, and faulting. At Broze Knoll, near Blue Mountain, a light-colored ash flow overlies one or more thin dark ones that differ chemically and modally from the Isom that they superficially resemble. Away from the Knoll, the light-colored tuff rests directly on parts of the Isom. The tuffs at Broze Knoll cannot be confidently correlated with the well-studied regional units.

The youngest rocks in the area are conglomerate and finer clastics, with interbedded flows that resemble basalts, that do not conform to the attitude of the underlying ash flows.

TABLE 1
Composition of the Escalante Desert Formation

Unit	A	B	C			D	
Sample number	74G329	74G331	74G334	74G335	74G335B	74G337	74G338
Modal analysis, %							
Quartz	1.0	1.0	1.3	0.5	1.9	0.0	0.0
Sanidine	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Plagioclase	1.4	2.7	2.7	5.5	2.7	11.6	8.5
Biotite	0.0	trace	0.3	trace	trace	2.1	1.6
Amphibole	0.0	0.0	0.0	0.0	0.0	trace	0.3
Opaques	trace	trace	0.1	trace	trace	1.2	0.1
Groundmass	85.8	91.0	89.3	93.4	92.0	69.3	67.8
Lithics	11.8	5.3	6.3	0.6	3.4	15.8	21.7
Plagioclase composition, %An	32	34	32		30	43	43
Color	5G6/1	5YR7/1	5YR7/1	5YR6/4	5R7/2	10R6/1	7YR6/6
Unit thickness, meters	1	8		69		29	
Unit	E				F		
Sample number	74G339	74G340	74G341	74G342A	74G344	74G345	74G346
Modal analysis, %							
Quartz	0.0	trace	trace	0.2	0.0	0.0	0.0
Sanidine	0.0	0.0	trace	trace	0.0	0.0	0.0
Plagioclase	15.8	10.6	5.8	9.7	10.5	17.2	8.2
Biotite	1.3	2.6	2.0	1.0	0.5	0.3	0.4
Amphibole	0.0	0.0	0.0	0.0	2.1	trace	0.1
Opaques	0.8	0.7	0.4	0.3	0.7	1.3	0.5
Groundmass	70.5	78.7	89.7	86.3	76.7	77.0	85.1
Lithics	11.6	7.4	2.1	2.5	9.5	4.2	5.7
Plagioclase composition, %An	46	46	46	45	43	42	43
Color	5YR5/2	5YR6/4	7YR4/2	5YR7/2	N3	2YR4/3	2YR7/2
Unit thickness, meters		58				21	

Note: Modal analysis used a 260-point grid, with points 0.2 mm apart, spotted every 5–10 mm along three traverses 10 mm apart (1800 points per thin section). Anorthite content was determined by twinning axis and plane locations, using tables and charts from Slemmons (1962) and Troger (1971). Lithic fragments were counted in hand specimen and the counts multiplied by the average thin-section-to-hand-specimen ratio.

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