Family Tree of USGS Soil Geomorphology Work in the Colorado Front Range and Adjacent Piedmont

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The Colorado Scientific Society is a Denver area group, composed mostly of geologists. In the fall of 2009 they honored the career of Glen Scott (Fig. 1), a 91-yr-old USGS geologist who had a diversified career that included some of the first soil geomorphology work on alluvium in the Denver area. Rich Madole and I were asked to address the group. Since Glen did some of the first work using soils to estimate ages and correlate alluviums in the Colorado Piedmont, Rich addressed their potentials and pitfalls 50 years later. I decided to go over the people who did the work in those 50 years. The "family tree" part of the title came from a new neighbor whose family just sold their California winery—the label was a tree with the different family contributors making up the branches. I thought the idea was perfect for this discussion because everybody's work relies of the work of others lower on the tree. Several days after the talks, Ralph Shroba joined us to co-lead a field trip in the piedmont to show how soils have helped shape our ideas on the geomorphic development of the landscape. To qualify for the tree, people have had to work for the USGS, or do work funded by the USGS, from the Continental Divide to the western plains in the greater Denver region. For the tree construction, focus was given to each person's first contribution.

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USGS Family Tree

Essentially, there are two branches of the family tree, one from the USGS, and the other from the University of Colorado (CU) (Fig. 2). The former will be discussed first. Charlie Hunt (Fig. 3) seems to have been most responsible for blending soils and geomorphology because he was chief of the General Geology Branch. He acquired his knowledge of soils during WWII when he was in the Military Geology Unit (MGU) of the USGS (Hunt, 1950). The unit consisted of 88 geologists (including Jim Gilluly, Gerry Richmond, Roger and Harriet Morrison, and Ed Eckel) and 11 pedologists (including Jim Thorp and Vladimar Sokoloff) (Terman, 1998). They produced 5000 maps, 2500 tables, and more than 300 reports addressing such things as terrain, trafficability, water sup-

Fig. 1. Glenn Scott.

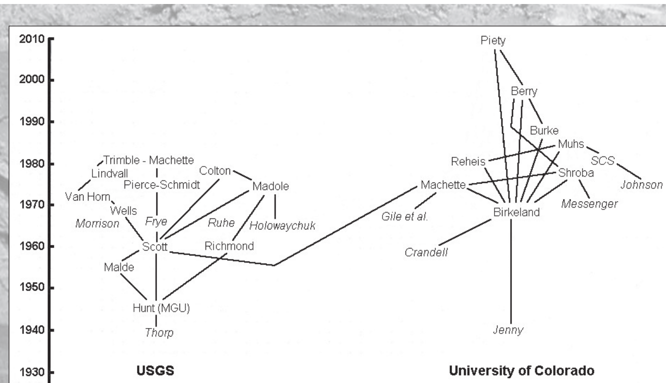

Fig. 2. University of Colorado.

Fig. 3. Charlie Hunt.

plies, and materials. These were produced rapidly to expedite the effort in the European Theater. Thorp (Fig. 4) was especially active in combining soils and geology since he had previously worked on the Pleistocene geology and soils in the Midwest, as well as loess and soils in China. Hunt (1954) used soils to help map alluvial units in the Denver area and, as chief, encouraged others to do so as well. Hunt and Sokoloff (1950) also published a paper on the pre-Wisconsin red soils in the Rocky Mountain region, a key paper used by many.

The next work was the Louisville Quadrangle by Malde (1955), which included the Rocky Flats Nuclear Weapons Plant (now called Rocky Flats Environmental Technology Site), as well as the type locality of Scott's (1960) Rocky Flats alluvium. He described units and soils but did not establish formal stratigraphic terms. He did, however, note the demarcation between calcic and noncalcic soils on the surface—no doubt due to the long-term precipitation gradient—now called the Malde line.

Scott (1963) mapped the Kassler Quadrangle, but earlier (Scott, 1960) formally proposed the stratigraphic units (alluviums), making extensive use of associated soils. One such soil was the old soil (about 2 Ma) Malde studied on Rocky Flats that was key to establishing the Rocky Flats alluvium (Shroba and Carrara, 1996). Holliday (2006) acknowledged Scott's work as one of the first attempts in the United States to use soils to estimate the ages of alluvial deposits and to correlate them from drainage to drainage. Scott mapped several other piedmont quadrangles (Scott, 1962, 1972), and later Scott and Taylor (1986) mapped Tertiary erosion surfaces in the Front Range. Soils have been used to help understand the erosion history of the more widespread surface (Birkeland et al., 2003).

At the same time, Richmond (1960) (Fig. 5) used soils to map and correlate glacial deposits in Rocky Mountain National Park, and later produced unpublished maps of many other areas in the Colorado Rocky Mountains. My interest in using soils in Quaternary geology was sparked by field trips both Scott and Richmond led in their respective areas at the 1960 GSA meeting in Denver. Richmond's monumental (1962) paper on the La Sal Mountains of Utah was the standard, as it showed how soils could be used to decipher Quaternary mapping units in any mountain range.

At this time, soils were being promoted for use in Quaternary stratigraphy by others, and this set the tone of the time. Prominent was Roger Morrison (Fig. 6), USGS–Denver, who produced some of the best maps ever of the lacustrice stratigraphy of Lake Lahontan, Nevada (Morrison, 1964) and wrote the book on soil stratigraphy (Morrison, 1978). Later, he and Richmond promoted their use in the formal stratigraphic code. John Frye was Chief of the Illinois Geological Survey and used field and laboratory properties of soils to set up the stratigraphic code of that state (Willman and Frye, 1970). Bob Ruhe (1969) (Fig. 7) used soils to decipher a comprehensive Quaternary history of deposits and the landscape in Iowa. All three (four if Richmond is included) were strong personalities and influenced many to use soils in Quaternary studies. Something was needed to help estimate ages of deposits because surface boulder weathering did not always give good answers due to fire-related surface spalling. The pointed debates of Frye and Ruhe were legendary and enlivened many a meeting and field trip, after which the two would go off for a beer. Ruhe was especially colorful. On many Midwest field trip stops in large quarries Bob would give his interpretation in another part of the same quarry, and he and the leader would banter back and forth.

Other people on this part of the tree mapped one or more quadrangles in which Scott's soil scheme was used to identify the Quaternary units (Wells, 1967; Van Horn, 1972; Lindvall, 1979). Toward the top

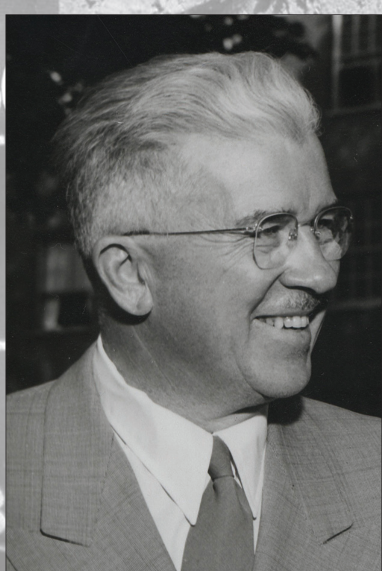

Fig. 4. Jim Thorp.

Fig. 5. G.M. Richmond.

Fig. 6. Roger Morrison.

of the tree Colton (1978) and Trimble and Machette (1979) published useful compilation maps in which soils were used extensively. Pierce and Schmidt (1975) deviated a bit by publishing a map showing various degrees of soil and weathered rock, mainly for land-use issues. What we call soil was described as "dirt"—maybe the first such formal use of that word, leading to a bit of humorous dialog.

Madole differs from many others in this part of the tree as he actually took soils courses from N. Holowaychuk, Ohio State University. For his Ph.D. he used soils to correlate glacial deposits in the mountains with alluvial deposits in the piedmont, separated by a canyon. At the USGS he was one of the few geologists to map both mountain (Gable and Madole, 1976) and piedmont (Madole et al., 1998) quadrangles. In later years he used soils to help with the ages of eolian sand deposits in the piedmont (e.g., 1995), and he presently is working on the Quaternary geology of the Boulder Quadrangle.

University of Colorado Family Tree

I am listed in the University of Colorado branch of the family tree, and I must confess I never took a formal course in soils (Fig. 8). My Ph.D. research was on the glacial geology in the Truckee area of the Sierra Nevada. I was having trouble using boulder weathering characteristics for age discrimination, and suspected spalling during forest fires was the reason. Rocky Crandell of the USGS was working on a review of west coast glacial geology for the 1965 INQUA volume and visited me. When he learned of the boulder weathering problem, he suggested I use something not affected by fire, the soil. So, he gave me a quick course on soils. When I obtained my degree, Hans Jenny (Fig. 9) hired me into the Dep. of Soils and Plant Nutrition, University of California–Berkeley, as he wanted a geology component in the course offerings. So I audited soils courses, went on field trips and mapped soils with Rod Arkley and Gene Begg. In 1967, I accepted a position at the University of Colorado, and that family tree began. One of my first papers at the University of Colorado was a grand correlation chart of the western United States, including the Front Range and piedmont, that used soils extensively, co-authored with Crandell and Richmond (Birkeland et al., 1971).

Machette (1977) (Fig. 13) mapped a piedmont quadrangle for his M.S. thesis, drawing on the work of Scott, and the carbonate stages of development of Gile et al. (1966). He also was the first to analyze the piedmont soils in the laboratory; in fact my students were responsible for setting up and equipping my lab via small grants from the graduate school dean. He later used soil carbonate to correlate soils across the western United States (Machette, 1985).

Before coming to the University of Colorado, Shroba (Fig. 10) had taken soil courses from A.S. Messenger (Northern Illinois University) and later mapped a piedmont quadrangle that included physical properties of many of the units (Shroba, 1980). He used soils to correlate deposits locally with those throughout the Rocky Mountains (Shroba and Birkeland, 1983) and also studied soils on Rocky Flats and vicinity (Shroba and Carrara, 1996). He later co-authored (Kellogg et al., 2008) a regional compilation map that includes both Front Range and piedmont, and his part relied a lot on soils for correlation. Before she was hired by the USGS, Reheis (1980) (Fig. 11) studied a transect across several drainages in the piedmont to show the influence of eolian dust on downwind soils; this was an outgrowth of a project in my soils course. Muhs also had more soil background than I, as he had taken soils courses from the soils department and Don Johnson (Fig. 12) at the University of Illinois and had mapped for the Soil Conservation Service. Before he joined the USGS, he obtained USGS funding to use


Fig. 7. Bob Ruhe.


Fig. 8. The author, Peter Birkeland.


Fig. 9. Hans Jenny.

soils to suggest a correlation between Holocene eolian deposits in the piedmont and glacial deposits in the cirques (Muhs, 1985). Once at the USGS he used soils and geochemistry to work out ages, source areas, and paleoclimate of eolian sand deposits and loesses in the piedmont (Muhs et al., 1996, 1999), as well as dust contribution to soils related to late Quaternary cirque glacial deposits (Muhs and Benedict, 2006). As with some of the studies listed above, the idea for this latter study for Muhs was a project for my Quaternary stratigraphy class.

The USGS had a large project on using soils to estimate ages of Quaternary deposits across the United States. They funded us (Birkeland et al., 1987) to study Holocene glacial deposits and soils in the Front Range. Shroba was one co-author, and co-author Burke (Fig. 11) went on to teach at Humboldt State University, where he taught Margaret Berry about soils before she did graduate degrees with me. She also provided a soil component to a general surficial map of the Denver area (Moore et al., 2001). One of Gerry Richmond's last projects was to map the general surficial geology of the US at 1:1,000,000 scale for the Quaternary Geological Atlas of the United States (USGS, 1983). Every place is depicted as some Quaternary unit, and the only true rock is in steep canyon walls. My former student Lucy Piety joined Richmond, Berry and others to work on the Pikes Peak map (in preparation).

We have felt an obligation to run soil-related field trips in the local area whenever professional groups come to town. Machette organized the first one (Machette et al., 1976) which was run in a snow storm (Fig. 13); my students helped by coming armed with brooms. Later Shroba and Madole have joined me and others to run trips and publish field trip guides (e.g., Birkeland et al., 1996; Dethier et al., 2003) and an article (Birkeland et al., 2003) on what we have learned to date in the area.

Summary

The soil geomorphologic work of the family tree individuals was essential, as we now have as good an understanding of the Quaternary history and soils of the range and piedmont as any such transect in the world. The work included creating mapping units, estimating ages, and inferring paleoclimate. They and other USGS colleagues have extended this work across the United States, and added the soil-neotectonic relationship to the mix. Many of them are now part of the USGS teams on Geology and Environmental Change and Geologic Hazards.

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Fig. 10. Ralph Shroba.

Fig. 11. Bud Birke and Marith Reheis.

Fig. 12. Don Johnson.

Fig. 13. (From left) Peter Birkeland (with microphone), Dan Muhs (with hood), Mike Machette (gray hat), and John Hawley (white hate).

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