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FACIES RECONNAISSANCE OF THE UPPER MIOCENE BIG SANDY FORMATION NEAR WIKIEUP, MOHAVE COUNTY, ARIZONA

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William R. Dickinson

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**Facies Reconnaissance of the Upper Miocene Big Sandy Formation near
 Wikieup, Mohave County, Arizona**

William R. Dickinson
Department of Geosciences, University of Arizona, Tucson AZ 85721

A brief reconnaissance (5-8 November 2008) of the Big Sandy Formation near Wikieup (on US Highway 93 in Mohave County, Arizona) was undertaken to reconcile a reported dominance of lacustrine beds (Sheppard and Gude, 1972, 1973) with the largely terrestrial mammalian fauna reported from the formation (MacFadden et al., 1979; Lindsay and Mead, 2005). The issue is resolved satisfactorily by appreciation that nearly all fossil localities occur in fluvial beds that intertongue with and grade laterally into the dominant lacustrine strata.

Outcrop Sketch Map

Figure 1 shows the distribution of exposures of the Big Sandy Formation near Wikieup. The map was prepared by adjusting the areal boundaries of outcrops of the Big Sandy Formation as shown by Sheppard and Gude (1973) by using airphotos on which Big Sandy outcrops are displayed by pale tints that contrast with the darker tones of younger overlying strata. Erosional outliers of the cover strata overlying Big Sandy Formation on multiple interfluves are not shown on the sketch map. The base of the Big Sandy Formation is exposed only along the southernmost limit of the outcrop belt along Box Canyon Wash just north of Signal Road, but even there the actual basal contact is obscured at all localities visited during this study by washfloor alluvium or slopewash. Younger strata of pediment bench gravels and progradational alluvial fans rest unconformably, with demonstrable scour and local paleovalley incision, on the Big Sandy Formation, which is also masked along the Big Sandy River by modern alluvium of the valley floor. The original Big Sandy facies mosaic was severely truncated by erosion before deposition of younger cover, and its full facies pattern can no longer be discerned. The locations of facies photographs (Figs. 2-4) are shown by labeled dots on the map (2A, 2B, 3A, 3B, 4A, 4B).

Dips of strata in the Big Sandy Formation are near horizontal, and nowhere $>2^\circ$ (Sheppard and Gude, 1972, p. C9) except near minor faults (displacement ≤ 4 m) in Natural Corrals Wash (Fig. 1). More steeply dipping mid-Tertiary strata occupying the preserved keels of local half-grabens (Scarborough and Wilt, 1979, p. 36-37, 80-81) are locally exposed upstream from the Big Sandy Formation in Burro Wash (Fig. 1) NNE of Wikieup, and in Tule Wash even farther north (off Fig. 1), but both tilted successions are overlain directly by post-Big Sandy bench gravels, and to the best of my knowledge are nowhere in contact with the Big Sandy Formation. A basalt flow within the tilted succession yielded a late Middle Miocene K-Ar age (WR) of 12.2 ± 0.2 Ma (Scarborough and Wilt, 1979, p. 37, 80, 100), much older than the Big Sandy Formation.

Big Sandy Age

The mammalian fauna of the Big Sandy Formation has been assigned (Lindsay and Mead, 2005) to the latest Miocene Hemphillian North American Land Mammal Age (NALMA). At the type locality, where the youngest beds of the Big Sandy Formation are exposed (MacFadden et al.,

1979), magnetostratigraphy indicates that the Big Sandy Formation does not extend upward beyond the lower part of magnetochron C3r, and is thus older than the Miocene–Pliocene time boundary at 5.33 Ma by the GTS 2004 timescale. Fission-track ages of intercalated ash beds, all within a tuffaceous horizon <10 m thick, range from 5.9 Ma to 5.0 Ma (n=3) with uncertainties (1σ) of 0.3–0.4 Ma, yielding a mean age (best estimate) of 5.5 ± 0.2 Ma (MacFadden et al., 1979). The magnetostratigraphic data imply, however, that the dated ash beds occur near the base of magnetochron C3An within a normal subchron that is assigned an age of 6.65–6.45 Ma by the GTS 2004 timescale. The age discrepancy of ~1 Ma between the mean fission-track age and the age derived from magnetostratigraphic correlation cannot be resolved with present information. Although previous workers have concluded that the Big Sandy Formation is either exclusively of Pliocene age (Sheppard and Gude, 1972, 1973) or includes strata of Pliocene age (MacFadden et al., 1979), neither of those conclusions is robust. Correlation of available magnetostratigraphy (MacFadden et al., 1979) with the GTS 2004 timescale implies deposition of the Big Sandy Formation within a short interval (6.7–5.6 Ma) of Late Miocene time (fully compatible with Hemphillian fauna).

The volcanic succession underlying the Big Sandy Formation has yielded K–Ar ages (WR basalt) of 8.8 ± 0.4 Ma and 8.2 ± 0.2 Ma (Late Miocene) where exposed in Burro Canyon southeast of Wikieup near the US Highway 93 bridge (Shafiqullah et al., 1980, p. 258; Ser. #142, samples UAKA-74-82 and UAKA 74-81, respectively). These dates bracket the maximum age of the Big Sandy Formation, but an erosional interval of unknown duration intervened between the basalt eruptions and Big Sandy sedimentation. A spurious K–Ar age of 9.6 ± 0.4 Ma (WR basalt) has been ascribed to the Big Sandy Formation on the basis of a lava flow allegedly intercalated within Big Sandy strata near a fossiliferous horizon (Shafiqullah et al., 1980, p. 257; Ser. #139, sample UAKA-70-13), but the latitude-longitude of the sample locality plots many miles to the southeast of the southernmost limit of Big Sandy outcrops, and the sample is inferred here to derive from the pre-Big Sandy volcanic succession. The erosional interval that preceded the deposition of pediment and fan gravels which overlie the Big Sandy Formation implies that the younger strata are entirely Pliocene or Pleistocene in age, but no isotopic or other age control for their deposition is available.

Big Sandy Facies

The maximum exposed thickness of the Big Sandy Formation is ~75 m (Sheppard and Gude, 1972). The areally most extensive facies is green to brown lacustrine mudstone (Fig. 1), evenly but massively bedded with sparse or weak lamination visible at selected horizons spaced at intervals within the lacustrine succession (Fig. 2). The typical bedding style is suggestive of largely hemipelagic deposition from the settling out of fine suspended sediment from muddy lakewater during intervals of clastic input from intermittent streamflow. Better lamination within thin interbeds of siltstone or fine sandstone, which grade upward into typical mudstone, probably reflect hyperpycnal underflow of turbid water from termini of input streams during flood events. Only limited scour beneath the siltstone and sandstone beds implies deposition from lacustrine density currents originating at fluvial termini along the lakeshore, rather than from subaerial streamflow across a dessicated lake floor. Intercalated within the lacustrine strata are at least a dozen massive to laminated tuff beds (Fig. 4A). Most are <25 mm thick individually although the two most extensive tuff horizons locally reach thicknesses of 150 mm each, and are termed

the lower and upper marker tuffs at horizons ~15 m and ~25 m, respectively, above the lowest Big Sandy horizons exposed (Sheppard and Gude, 1972).

The type section between Wikieup and Bitter Creek (Fig. 1) was not visited because ready access could not be arranged during my brief sojourn in Wikieup to a gated community (Cholla Canyon Ranch) located at or near Cofer Hot Springs (Fig. 1), nor to adjoining posted lands owned by the Hualapai tribe. A measured section and photograph (Sheppard and Gude, 1972) imply that the type section (~60 m of strata) is typical mudstone of the lacustrine facies, as is reference section R-1 (~17.5 m of strata) in bluffs beside the Big Sandy River southwest of US Highway 93 (near the roadcut of Figure 2A).

Successions of sandstone and conglomerate that interfinger with lacustrine strata of the Big Sandy Formation display clearcut fluvial characteristics (Fig. 3): irregular or lenticular bedding, basal scour beneath individual beds, calcareous pedogenic nodules, and imbricated pebble stringers reflecting bedload deposition during streamflow (Fig. 4B). The largest clasts observed during my visit are pebbles, but clasts evidently reach diameters of ~50 mm locally (Sheppard and Gude, 1973). Sheppard and Gude (1973, p. 4) concluded that the sandstone and conglomerate beds “may be fluvial” and occur “marginward” from the more “basinward” lacustrine mudstone, but my reconnaissance documented tracts of undoubted fluvial facies near the southern and northeastern limits of Big Sandy exposures (Fig. 1). The laterally gradational contacts shown with lacustrine facies were poorly controlled, however, during my brief study, and as mapped may well be overly simplified or somewhat misplaced. Reference sections R-2 (~25 m of strata) and R-3 (~40 m of strata) both lie within the southern fluvial facies near Box Canyon Wash, and are composed dominantly of fluvial sandstone and siltstone with minor conglomerate (Sheppard and Gude, 1972).

Fluvial paleocurrents defined by pebble imbrications document paleoflow lakeward toward the southwest within the northern fluvial facies and toward the northeast within the southern fluvial facies. Sheppard and Gude (1973) inferred that the Big Sandy lake spilled over to the south as the lake basin filled with sediment, with the outflow subsequently dissecting the sill or barrier that had dammed the lake. The Big Sandy lacustrine facies is bordered, however, as firmly and apparently as continuously to the south as to the north by fluvial facies displaying lakeward paleocurrent indicators. This observation suggests that drainage of the lake and dissection of the lakebeds followed stream capture of the lake basin by headward erosion from an ancestral Big Sandy River working northward from the Bill Williams–Santa Maria trunk drainage. Zeolitic facies in altered tuffs of the Big Sandy Formation imply diagenesis by pore waters beneath a confined saline and alkaline lake (Sheppard and Gude, 1973). Removal of the uppermost lake deposits by erosion makes any interpretation for the demise of the lake difficult to confirm or deny, but there is no reported or readily observable evidence from the preserved lake deposits for shoaling of the lake over time, nor from the southern fluvial facies for fluvial outflow from the lake.

Big Sandy Fauna

The Big Sandy local fauna (MacFadden et al., 1979; Lindsay and Mead, 2005) includes a rich diversity of mammalian quadrupeds (bear, camel, cat, dog, fox, horse, llama, marten, mouse,

pronghorn, rabbit, ringtail, skunk, weasel, wolverine) as well as one of the most diverse Late Miocene avian faunas known from North America. Of ~40 avian taxa, ~70% are aquatic forms or shorebirds (avocets, cranes, ducks, flamingos, geese, godwits, grebes, gulls, plovers, rails, sandpipers, stilts, swans), but doves, eagles, hawks, storks, and vultures are also represented. Fossils of any kind are rare, however, throughout most Big Sandy exposures, with nearly all collections from localities (Grey's Ranch, Clay Bank, and Bird Bone quarries of MacFadden et al., 1979) that lie within the southern fluvial facies near Box Canyon Wash near the southern limit of Big Sandy exposures (Fig. 1). The suggestion has been made that floating dead carcasses were concentrated along the southern shore of a Big Sandy lake by northerly winds, but it seems more likely that the rich fossil beds are deposits of lakeshore paleoenvironments or of a local lacustrine delta where the remains of aquatic birds and herbivorous terrestrial mammals could be commingled, together with the remains of both avian and non-avian predators and scavengers attracted to the lakeshore by abundant prey species. It is notable that no fully aquatic mammals (turtles, etc.) have been reported from the Big Sandy Formation. To my mind, the restriction of rich fossil beds to a lake-margin fluvial facies, perhaps including interbeds of marginal-lacustrine strata, fully accounts for the fossil occurrences, and explains satisfactorily why diverse terrestrial mammalian taxa are so abundant in the local fauna of a formation that is dominantly lacustrine in areas removed from the fossil concentrations.

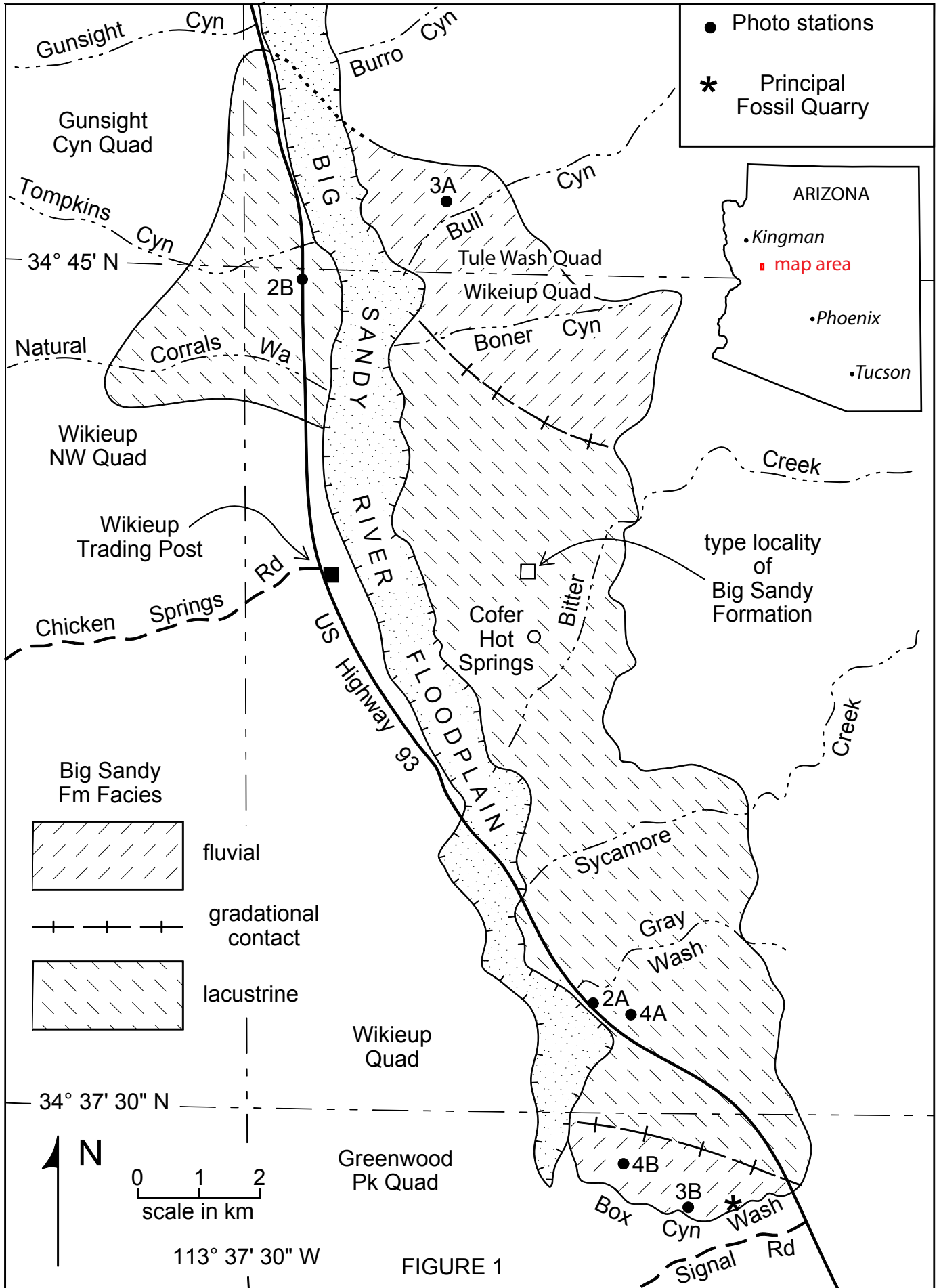
Acknowledgments

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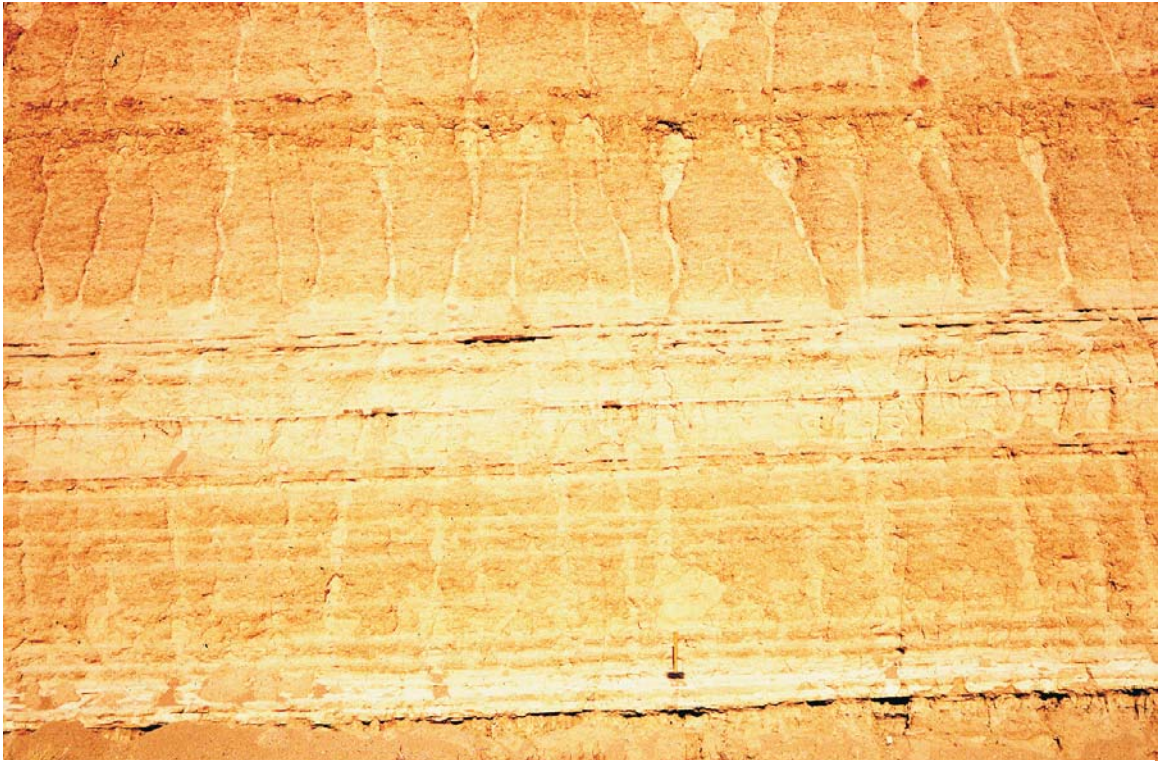


Figure 2. Big Sandy Lacustrine Facies

top (A): even-bedded strata in roadcut on northeast side of US Highway 93 (SSE of Wikieup near west edge of Section 18, T. 15 N., R. 12 W., Wikieup Quad) just south of Gray Wash [hammer near bottom center for scale]

bottom (B): laterally continuous thin beds in roadcut between divided lanes of US Highway 93 (view toward west) between Natural Corrals Wash and Tompkins Canyon (due north of Wikieup near boundary between Sections 3 and 10, T. 16 N., R. 13 W., Wikieup Quad)



Figure 3. Big Sandy Fluvial Facies

top (A): sandy fluvial succession with pedogenic carbonate nodules (pale coloration) in roadcut on west side of Wikieup Back Road [hammer at lower left for scale] just north of Bull Canyon (NNE of Wikieup near north edge of Section 2, T. 16 N., R. 13 W., Tule Wash Quad)

bottom (B): lenticular fluvial beds (pebbly sandstone) in north wall of north fork of Box Canyon Wash near wash forks (ESE of Wikieup near west edge of Section 29, T. 15 N., R.12 W., Greenwood Peak Quad); WSW of US Highway 93 [hammer near top center for scale]



Figure 4. Special Big Sandy Features

top (A): laminated thin tuff beds (resistant) in lacustrine facies exposed in artificial cut within alcove in cliffs behind Enviroverde Mohave Pit (SSE of Wikieup near center of Section 18, T. 15 N., R. 12 W., Wikieup Quad); NE of US Highway 93 SE of Gray Wash [hammer for scale]

bottom (B): imbricated pebble horizon (paleoflow to N70E subparallel to hammer handle) in fluvial strata exposed in streamcut beside 4WD track SW of US Highway 93 near mouth of Box Canyon Wash (SSE of Wikieup near north edge of Section 30, T. 15 N., R. 12 W., Greenwood Peak Quad)