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THE UPPER CRETACEOUS RINGBONE FORMATION, LITTLE HATCHET MOUNTAINS, SOUTHWESTERN NEW MEXICO

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Abstract—The nonmarine Upper Cretaceous Ringbone Formation in the Little Hatchet Mountains consists of conglomerate, sandstone, siltstone and mudstone. Deposition of Ringbone strata accompanied basin development during an early phase of the Laramide orogeny. Ringbone strata crop out in several areas in the northern part of the Little Hatchet Mountains. Near Playas Peak, the Ringbone Formation rests disconformably on the upper Albian to lower Cenomanian Mojado Formation and is overlain unconformably by the lower Tertiary Skunk Ranch Formation. In its northernmost exposure, the Ringbone Formation is interbedded with the Hidalgo Formation. Ringbone strata attain a maximum thickness of 1608 m and are divided into three informal lithostratigraphic members. Strata in the lower member have a maximum thickness of 120 m and consist predominantly of sedimentary-clast conglomerate derived from Lower Cretaceous and Paleozoic sedimentary rocks that were located to the northwest. Conglomerate successions in the lower member are interpreted as alluvial-fan and braided-stream deposits. The middle member attains a maximum thickness of 1095 m and was deposited by a northeast-draining paleofluvial system that flowed nearly orthogonally to that of the lower member. Delta-plain, marginal lacustrine deltaic and lacustrine deposits also characterize the middle member. Rhyolitic to quartz latitic or rhyodacitic air-fall tuffs permit stratigraphic correlation between geographically separated exposures. Dinosaur remains indistinguishable between *Albertosaurus* or *Daspletosaurus* and well preserved hadrosaur skin impressions and skeletal material (vertebrae and ossified tendons) indicate a late Campanian to early Maastrichtian age for this member. The upper member attains a maximum thickness of 393 m and is mainly composed of coarse-grained sedimentary litharenite and conglomerate of braided-fluvial and alluvial origin. Beds of volcanic-clast conglomerate are interbedded with upper member sedimentary strata and increase in abundance in the northern exposure. The stratigraphic relationship between the compositionally distinct Hidalgo and Skunk Ranch formations supports the interpretation that the early Laramide basin, represented by the Ringbone Formation, was partitioned by a subsequent phase of Laramide deformation.

INTRODUCTION

The Upper Cretaceous Ringbone Formation is a nonmarine unit that documents a unique chapter in the history of Laramide basin development in the Little Hatchet Mountains of southwestern New Mexico. Unraveling the stratigraphy of the Ringbone Formation, as well as the Upper Cretaceous–Paleogene stratigraphic successions associated with the Ringbone, is a challenging endeavor.

A complicated post-Ringbone geologic history that included orogenesis and fault reactivation, as well as diverse lithologies and poor exposures of the Ringbone Formation, led to differing stratigraphic interpretations by previous geologists. Lasky (1947) and Zeller (1970) differed in their interpretations of the Ringbone Formation. Lasky (1947) identified the Ringbone Shale as predominantly black bituminous shale and mudstone in the northern part of the Little Hatchet Mountains near the Ringbone Ranch. The type locality for the Ringbone Formation designated by Zeller (1970), also near the Ringbone Ranch, included a basal sedimentary-clast conglomerate (the Broken Jug Limestone of Lasky, 1947), the Ringbone Shale, and parts of the Hidalgo Volcanics of Lasky (1947).

The Ringbone Formation, as defined here, includes the Broken Jug Limestone, the Ringbone Shale, the Howells Ridge Formation, the Playas Peak Formation and the lower part of the Skunk Ranch Conglomerate of Lasky (1947). The Ringbone Formation described here closely coincides with that of Zeller (1970), except southwest of Playas Peak (Fig. 1). Strata exposed south and west of Playas Peak and mapped as Ringbone by Zeller (1970) have been interpreted as late Paleocene to Eocene in age (Lawton et al., 1990, 1993) based on an ostracode fauna. This upper Paleocene unit, here referred to as the Skunk Ranch Formation, includes the upper part of the Skunk Ranch Conglomerate of Lasky (1947) and is not included in the Ringbone Formation (Wilson, 1991). This paper presents a summary of work documented in Basabilvazo (1991) regarding the detailed stratigraphy, new interpretations of depositional environments, and a better-constrained age for the Ringbone Formation in the Little Hatchet Mountains of southwestern New Mexico.

Lawton et al. (1993) presented a comprehensive redefinition of the Upper Cretaceous and Paleogene stratigraphic succession and interpreted tectonic controls and phases of basin development related to Laramide strata of the Little Hatchet Mountains in southwestern New Mexico. However, some uncertainty still exists regarding the relationships of the Ringbone Formation, Skunk Ranch Formation, and the Hidalgo Formation.

METHODS

Methods employed in this study included measured stratigraphic sections, sandstone petrography, paleocurrent measurements on trough cross-stratification limbs and imbricated clasts, clast counts for provenance determination, and reconnaissance mapping of the study area. Comprehensive mapping of the study area is described in Hodgson (1991, this volume). Reconnaissance mapping provided guidance for identifying acceptable locations for measured sections.

STRATIGRAPHY AND AGE

The Ringbone Formation has a maximum thickness of 1608 m and consists of conglomerate, sandstone, siltstone, and mudstone. The formation is exposed in three blocks separated by reverse faults (Fig. 1). Three major stratigraphic sections were measured, one on each fault block (Fig. 1). Stratigraphic successions, silicic air-fall tuffs, and dinosaur remains permit correlation of the three sections.

The Ringbone Formation rests unconformably on the Lower Cretaceous Mojado Formation (Zeller, 1970). At its southernmost exposure, the Ringbone Formation is overlain unconformably by the lower Tertiary Skunk Ranch Formation. In the two northern blocks (Fig. 1), the Ringbone Formation interfingers with the Hidalgo Formation. The Hidalgo Formation may be a lateral equivalent to the Skunk Ranch Formation (Lawton et al, 1993).

The Ringbone Formation consists of three informal lithostratigraphic members (Fig. 2). These informal members record synorogenic sedimentation in an early Laramide basin. A subsequent phase of Laramide deformation resulted in renewed sedimentation represented by the upper member of the Ringbone Formation and the Hidalgo and Skunk Ranch formations (Hodgson, 1991; Lawton et al., 1993).

Lower member

The lower member of the Ringbone Formation is best exposed on the southern and northern blocks and rests disconformably on the upper Albian to lower Cenomanian Mojado Formation (Fig. 1). The lower member varies from 55 to 120 m thick and is characterized by medium to thick beds of sedimentary-clast conglomerate lacking cross stratifi-

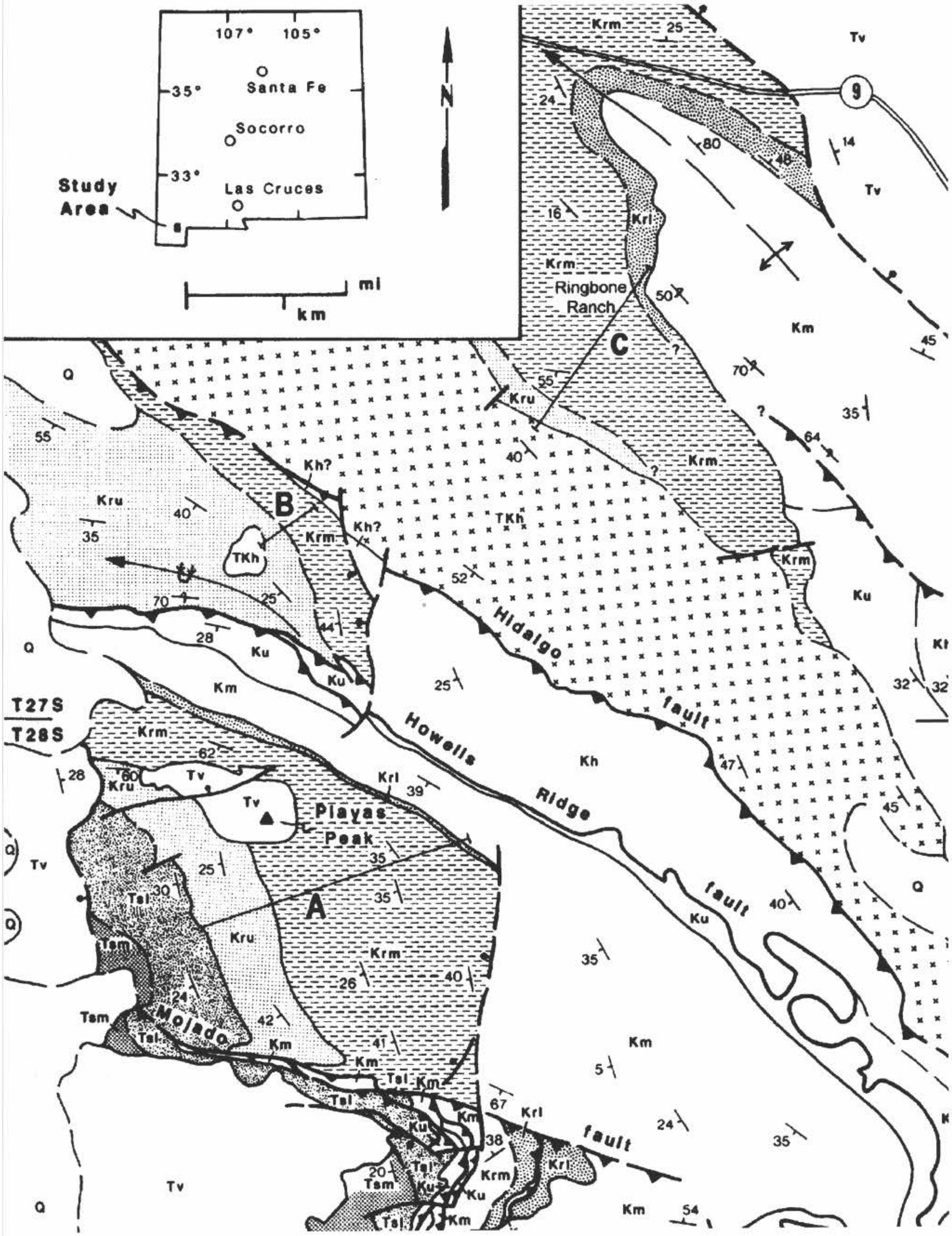

FIGURE 1. Geologic map of northern part of the Little Hatchet Mountains, modified from Lawton et al. (1993). Generalized measured sections in Figure 2 indicated by line segments A, B, C. Kh, Hell-to-Finish, Ku, U-Bar, and Km, Mojado formations; Ringbone Formation, divided into lower (Krl), middle (Krm), and upper (Kru) members; TKh, Hidalgo Fm; Skunk Ranch Formation, divided into lower (Tsl), middle (Tsm), and upper (Tsu) members; Tv Eocene and Oligocene volcanic rocks; Q, Quaternary deposits.

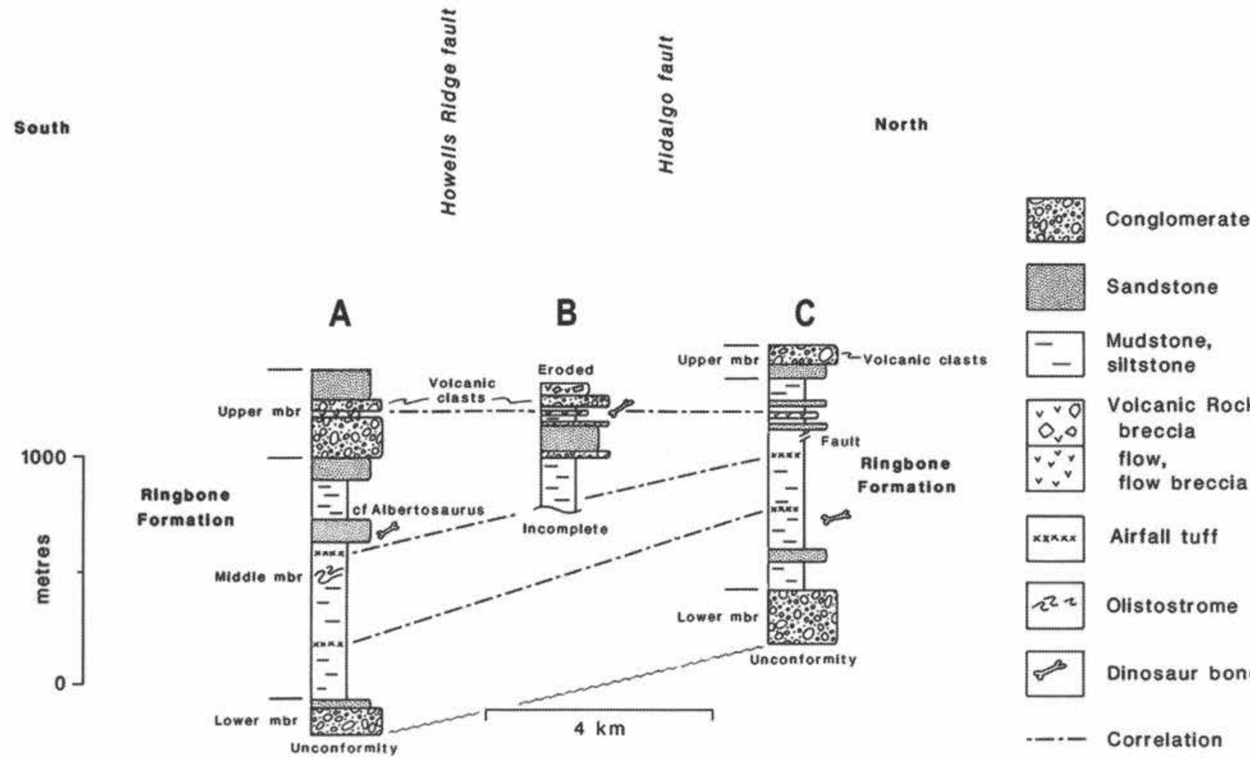

FIGURE 2. Generalized stratigraphic sections of the Ringbone Formation in the northern Little Hatchet Mountains, New Mexico. Locations of measured sections are shown in Figure 1. Lithologies are generalized and represent dominant rock types. Modified from Lawton et al. (1993).

cation, interbedded with thin to medium beds of sublitharenite to litharenite (Fig. 3A). Individual conglomerate beds are structureless, coarse grained, and have a sheet-like geometry.

The beds in the lower member of the southern block thin westward to a truncation at a normal, range-bounding fault (Fig. 1). Geologic mapping (Hodgson, 1991) delineated this previously unrecognized north–south-trending normal fault that down-dropped the lower member on the southern block into the subsurface.

Strata in the lower member of the southern block are interpreted as proximal, flashy, braided-stream deposits (Fig. 3B). These strata closely resemble braidplain deposits described by Rust (1972), Jackson (1978), and Rust and Koster (1984) and the idealized Scott-type facies model of Miall (1978). The lower member of the northern block is interpreted as alluvial-fan deposits (Fig. 3A) that grade vertically into braidplain deposits. These alluvial-fan deposits of the northern block closely resemble deposits described by Rust and Koster (1984). Conglomerate characteristics indicate that the paleoflows were competent and that flow strength decreased rapidly downstream.

Imbrication measurements and provenance interpretations of clasts in the coarse-grained sedimentary-clast conglomerate beds of the southern block indicate that braided streams or rivers transported Lower Cretaceous and Paleozoic detritus in a southeasterly–southerly direction (Basabilvazo, 1991). About 5% of the clasts in conglomerate beds north of Playas Peak consist of green to gray andesitic volcanic clasts of probable Late Jurassic age. The paleofluvial system is interpreted to have been oriented parallel to structural trends that developed prior to or concomitantly with the deposition of Ringbone strata. Paleozoic clasts in conglomeratic beds indicate stripping of cover down to the level of the Aptian Hell-to-Finish Formation that consists of Paleozoic-clast conglomerate. The source of the sedimentary clasts is speculated to have been an uplift located to the northeast.

Middle member

The middle member is best exposed on the southern block east of Playas Peak, where it is approximately 1095 m thick and consists of two upward-coarsening successions (Fig. 2). The dominant lithologies of the coarse-grained intervals are medium- to coarse-grained sandstone with pebble lags interbedded with olive-green mudstone. The dominant lithologies of the fine-grained intervals are fine- to medium-grained feldspathic litharenite interbedded with olive-green to black, fossiliferous mudstone.

The sandstone beds in the fine-grained intervals are usually <1 m thick. The sandstones contain trough cross-stratification, have crude upward-fining textural trends and minor amounts of horizontal lamination, all indicating deposition in channels. The sandstone channels are usually <1.5 m thick, have sheet and ribbon geometries with rare cutbanks or lateral-accretion bedding. Each sandstone interval typically is separated by intervals of thicker, sparsely fossiliferous mudstone (Fig. 3C). This geometry represents a slightly sinuous, low-gradient fluvial system that is interpreted to have developed on a delta plain or alluvial plain. The color of the interbedded mudstone generally varies from olive-green to greenish brown near the bottom of the succession and upsection becomes dark olive-green to black. These deposits are interpreted as delta-plain and marginal-lacustrine deposits. The deposits of the Ringbone Formation closely resemble strata from the Green River Formation in Wyoming interpreted by Ryder et al. (1976) as delta-plain and lacustrine-margin deposits.

Sandstone beds in the coarse-grained intervals typically exhibit multi-story ribbon and sheet geometries with medium- to large-scale trough cross-stratification and minor amounts of channel-fill trough cross-stratification similar to that described in Singh (1972) (Fig. 3D). Abundant trough cross-stratification indicates deposition by migration of large, three-dimensional bedforms. In addition, rip-up clasts at the bases of troughs, pebbles, and oxidized and lithified organic fragments were observed. Sandstone beds are interbedded with sparsely fossiliferous olive-green to black mudstone. A high rate of aggradation is indicated, based on the lack of lateral-accretion foresets, rare cut-bank margins, and well-preserved channel geometry.

Measurements of limbs from trough cross-stratification in sandstone beds indicate that the middle member was deposited by a northeasterly flowing paleofluvial system that was oriented nearly orthogonally to the dispersal system of the lower member. In addition, there were

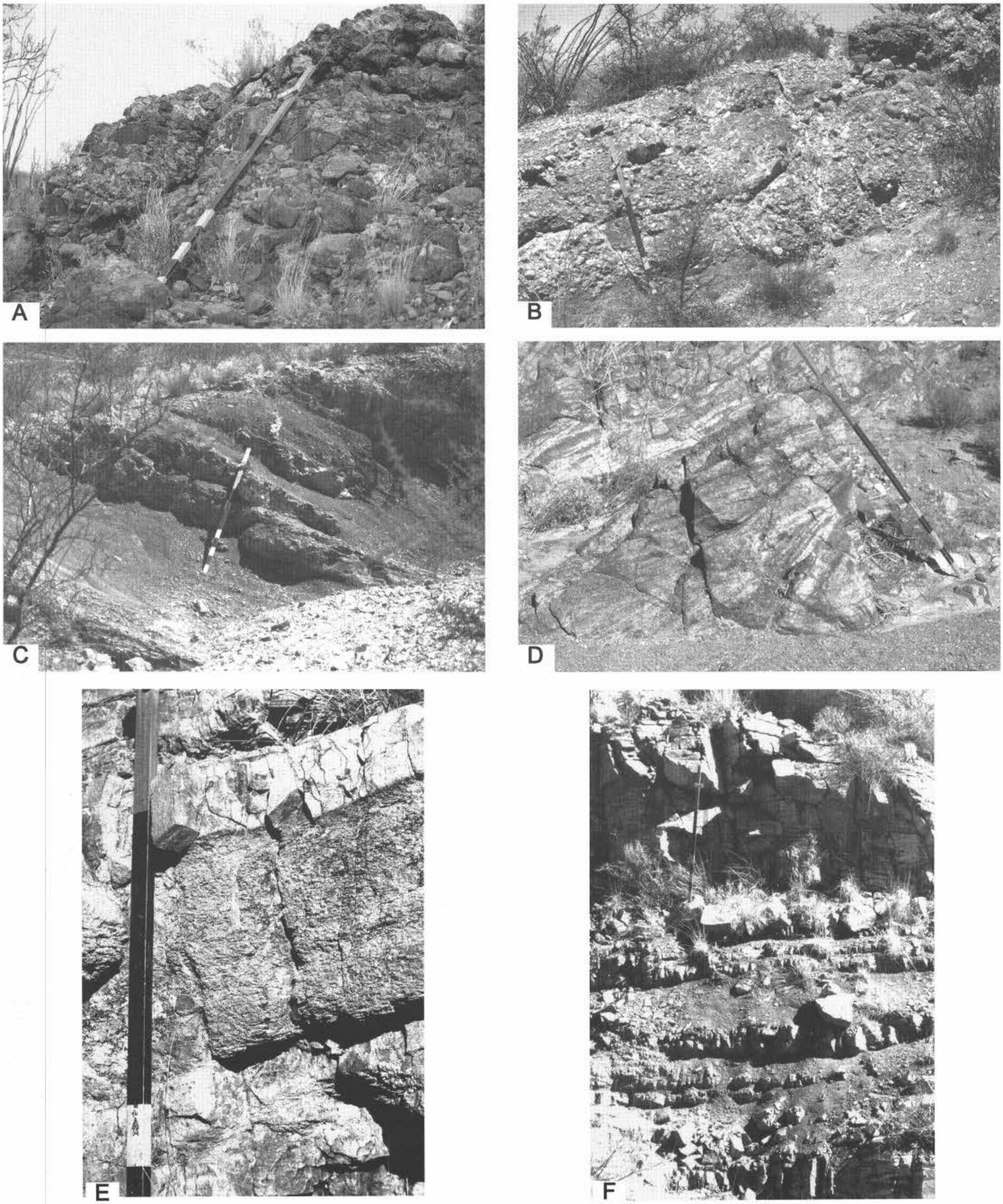

FIGURE 3. Photographs of selected Ringbone Formation outcrops in the northern Little Hatchet Mountains. Note Jacob staff for scale. **A**, Sedimentary-clast conglomerate of lower member in the northern block. **B**, Sedimentary-clast conglomerate of lower member in the southern block. **C**, Typical feldspathic sandstone and interbedded slightly fossiliferous mudstone of the middle member. **D**, Typical coarse-grained, cross-bedded feldspathic sandstone in the middle member. **E**, Medium-bedded, air-fall tuff in the middle member. **F**, Upward-coarsening deltaic sandstone succession in the middle member.

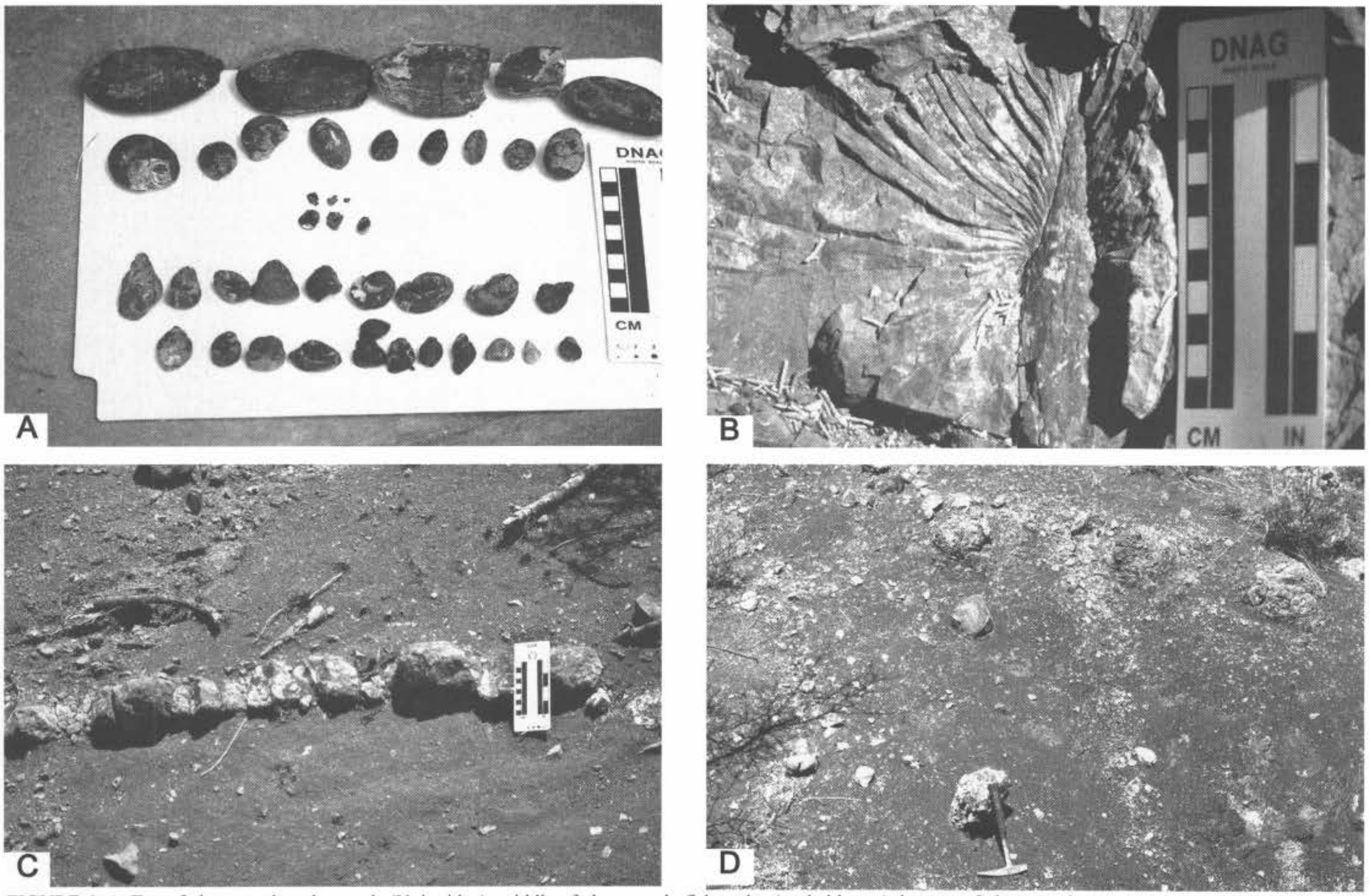

FIGURE 4. **A**, Top of photograph, pelecypods (Unionidae); middle of photograph, fish scales (probable gar); bottom of photograph, gastropods (*Physa*, *Viviparus* sp.) all from the middle member. **B**, Part of a palm leaf impression (*Sabalites* sp.). **C**, Ringbone lacustrine strata composed of thick, structureless fossiliferous mudstone interbedded with a thin, sandy, bioclastic bed in the middle member. **D**, Olistostrome deposit in Ringbone lacustrine strata. Note boulder composed of sedimentary-clast conglomerate weathering out of the fossiliferous mudstone and boulder-size calcareous bioclastic nodules near top center of photograph (geologic pick for scale).

changes in grain size and composition representing a transition from longitudinal braidplain (lower member) to a transverse delta or alluvial plain (middle member).

Two laterally continuous air-fall tuff deposits are present in this member and permit correlation of the measured sections on the southern and northernmost blocks (Fig. 2). The air-fall deposits thicken and thin locally but generally thin westward. These deposits typically are white to greenish yellow and are commonly cherty in appearance, biotite-rich, and thin- to medium-bedded with planar tops (Fig. 3E). Thin-section examination indicates that the air-fall tuffs consist of glass shards, feldspar, quartz, and biotite. Accretionary lapilli with a glassy matrix and radial glassy margins were observed in a sample collected from the lower air-fall tuff in the middle member (Basabilvazo, 1991). Vertical rhizoliths and plant impressions were observed on the top of the upper air-fall tuff. Sandstone channel deposits above these air-fall tuffs rarely have rip-up clasts of tuff, indicating that in most instances, fairly rapid sedimentation followed deposition of the volcanic material. Based on composition and comparison to similar deposits described by Ross and Smith (1961), the air-fall tuffs in the Ringbone strata represent rhyolitic to quartz latite or rhyodacite pyroclastic deposits

A thick-bedded succession of abundantly fossiliferous mudstone and horizontally laminated to trough cross-stratified sandstone deposits, between 460 m and 680 m thick (Fig. 2, section A), are expansions and contractions of a lacustrine environment on a low-relief lacustrine margin. Deltaic subenvironments recognized in this horizon include interdistributary deposits, delta-front sands and distributary channels (Fig. 3F). These successions typically consist of thinly interbedded fine- to medium-grained sandstone and fossiliferous mudstone that coarsen upward to multistory sandstone with molluscs and pebble lags (Fig. 3F). Interfingering of subaerially exposed marginal-lacustrine deposits with open-lacustrine deposits is interpreted from thick, fossiliferous, black mudstones overlain by rooted sandstones. Fossils are illustrated in Figure 4A and include conispiral gastropods (*Physa*, *Viviparus* species), Unionid-pelecypods and fish scales (probable gar species, S. G. Lucas, personal commun. 1989). In addition, palm leaf impressions (*Sabalites*) (Fig. 4B), horse tails (*Equisetites* roots; J. F. Schreiber, personal commun., 1989), several silicified tree remains in growth position and coniferous leaf impressions were observed on crevasse-splay-like deposits in the middle and upper parts of the middle member. The abundance of these fossils indicates a prolific marginal-lacustrine and lacustrine environment.

The open-lacustrine deposits include thick, structureless-to-black, fissile, fossiliferous mudstone interbedded with thin beds of fine-grained sandstone and discontinuous bioclastic limestone, bioclastic sandstone and calcareous nodules (Fig. 4C). The mudstone contains abundant large gastropods (3–5 cm) and pelecypods (4–10 cm). The sandy bioclastic limestone commonly consists of accumulations of a single molluscan species. Bioclastic limestone beds are deposits of molluscs transported by storms from the marginal-lacustrine environment; bioclastic sandstone beds are as delta-front deposits. These lithologies closely resemble deposits of ancient and recent lacustrine successions described by Picard and High (1981), ancient lacustrine sequences described by Link and Osborne (1978) from the Pliocene Ridge Basin Group, and by Ryder et al. (1976) and Fouch and Dean (1982) from the early Tertiary Uinta basin.

A unique characteristic of the open-lacustrine deposits is the occurrence of an olistostrome deposit. The olistostrome deposit is characterized by boulder-size blocks that consist of well-rounded pebbles and cobbles of limestone and chert, articulated pelecypods, well-preserved gastropods and less-common silicified bones and tree fragments, all in a yellowish-orange, calcareous, siltstone matrix interbedded with black structureless mudstone (Fig. 4D).

Several dinosaur fossils were recovered from deltaic and lacustrine deposits from 1989 to 1990. These dinosaur fossils constrain the age of the middle member between late Campanian and Maastrichtian (Lucas et al., 1990). They include an incomplete *Albertosaurus* tooth and a vertebral centrum resembling the anterior caudal centra of either *Albertosaurus* or *Daspletosasurus* (Lucas et al., 1990). In addition, well-preserved dinosaur skin impressions and skeletal material (vertebrae and ossified tendons) were also recovered (Figs. 5A, 5B). Also, a bone identified by Lucas (1993) as the incomplete humerus of a hadrosaurid (Fig. 5C) was found in the middle member in the northern block. Preservation of soft tissue is rare in the fossil record and preservation and discovery of skin impressions in Ringbone strata are undoubtedly related to unique circumstances. The skin impressions and associated skeletal remains were recently described in detail and identified as that of a hadrosaur (Anderson et al., 1998).

Depositional environments recognized in the middle member are delta-plain and paludal deposits that grade up-section into marginal-lacustrine (deltaic) and lacustrine deposits. These environments occasionally received volcanic ash as indicated by the air-fall tuff deposits. In addition, the fossils indicate a robust, vegetated, delta plain and marginal-lacustrine environment in an intermontane basin. The sedimentary structures of the lacustrine strata, which include fissile black fossiliferous mudstone, olistostrome deposits and relatively thick deltaic sandstone, support the interpretation that this was a lake of considerable depth. The abundance and diversity of fossils conjure up classic artists' renditions of palm trees interspersed among low-lying vegetation with dinosaurs living and hunting along the deltaic and lacustrine margin, with fish foraging in the subaqueous environments, and molluscs living in and on the substrate.

Upper member

Compositional change in the sandstones from feldspathic litharenites (middle member) to sublitharenites (upper member) and a general increase in grain size and thickness of sandstone deposits characterize the upper member. The best exposure of the upper member is southwest of Playas Peak (Fig. 1), where it is approximately 393 m thick. Southwest of Playas Peak, the upper member is overlain unconformably by the lower Tertiary Skunk Ranch Formation (Basabilvazo, 1991; Fig. 1).

The upper member consists of sedimentary-clast conglomerate, medium to pebbly trough cross-stratified and horizontally laminated litharenite and mudstone. Conglomerate clasts are dominantly composed of sedimentary lithologies, mainly limestone and chert. However, volcaniclastic deposits interfinger with the sedimentary-clast conglomerates on all three blocks (Fig. 2). The volcaniclastic deposits are composed of a crudely stratified to unbedded mix of pebbles and cobbles of porphyritic andesite and aphanitic, lithic volcanic grains. Volcaniclastic

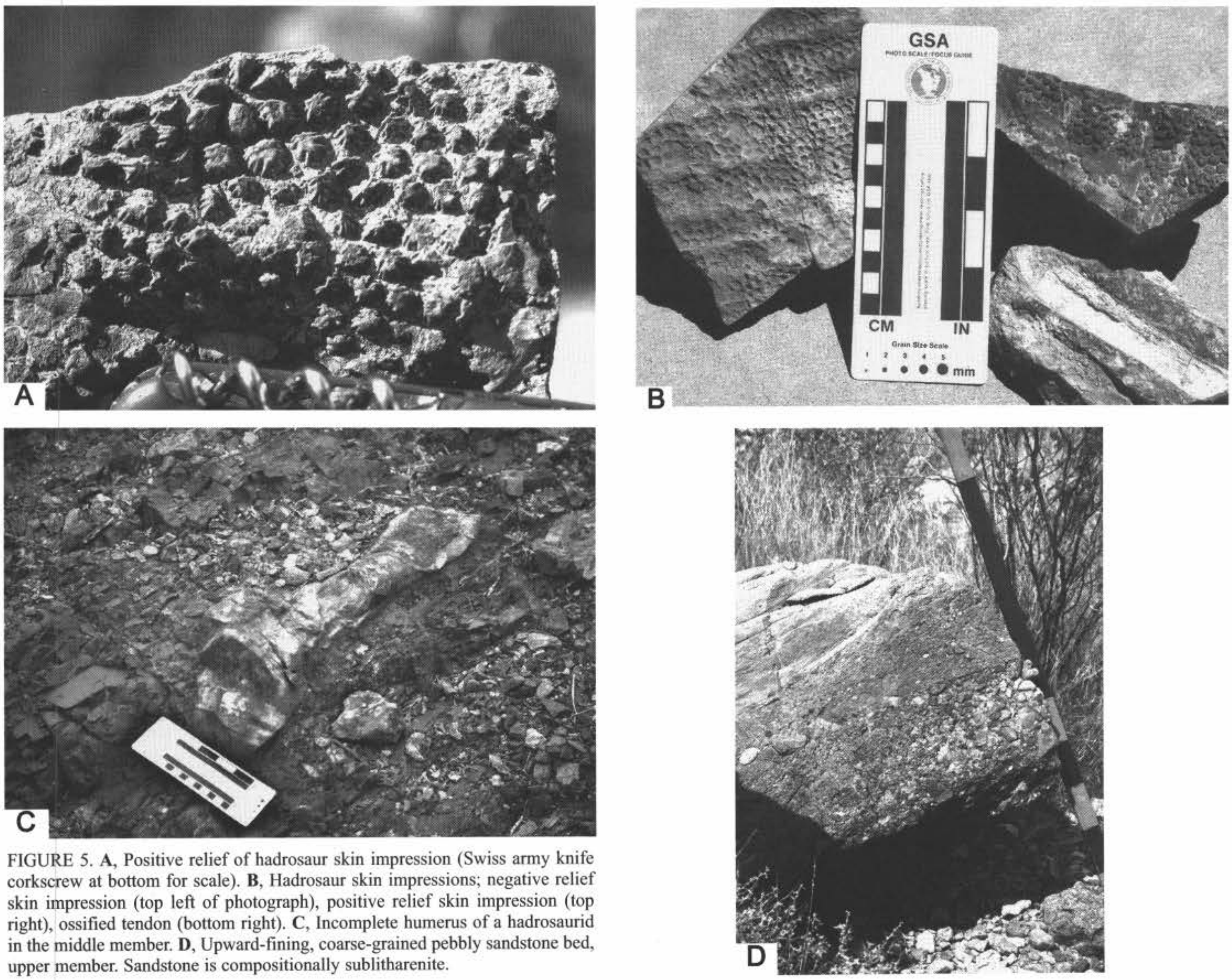

FIGURE 5. **A**, Positive relief of hadrosaur skin impression (Swiss army knife corkscrew at bottom for scale). **B**, Hadrosaur skin impressions; negative relief skin impression (top left of photograph), positive relief skin impression (top right), ossified tendon (bottom right). **C**, Incomplete humerus of a hadrosaurid in the middle member. **D**, Upward-fining, coarse-grained pebbly sandstone bed, upper member. Sandstone is compositionally sublitharenite.

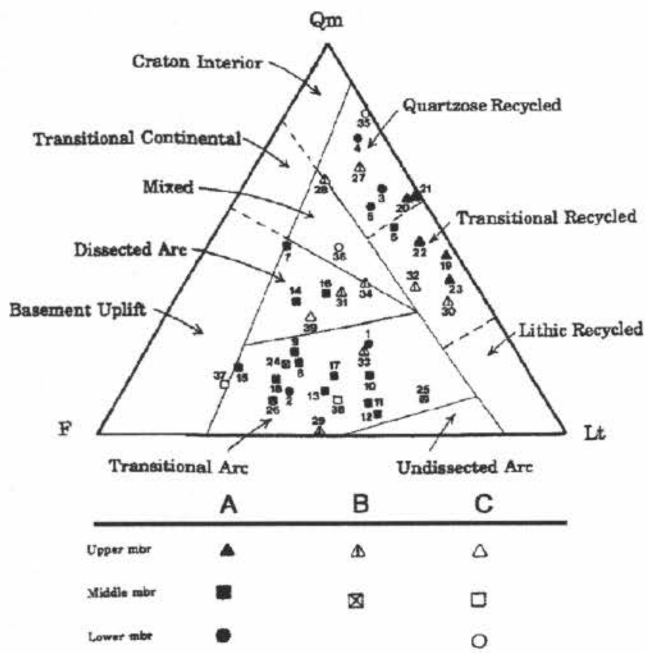

FIGURE 6. Ternary plot of modal compositions of Ringbone Formation sandstones. Qm, monocrystalline quartz; F, total feldspar, Lt, total lithic grains. Provenance fields are from Dickinson and Suczek (1979). Locations of measured stratigraphic sections (A–C) shown in Figure 1. Numbers correlate to thin sections from Basabilvazo (1991).

deposits in the upper member increase in abundance on each block to the north.

Individual sedimentary-clast conglomerate beds range in thickness from 1 to 10 m and are interbedded with coarse-grained sublitharenite and olive-green mudstone. Small molluscan fossils are uncommon in the mudstones. In addition, silicified tree fragments, plant impressions, and dinosaur bones are rare but characteristic of the upper member. Beds of sedimentary-clast conglomerate and sublitharenite exhibit upward-fining successions.

The upper member is interpreted as a braided-stream deposit. These deposits resemble those of the lower member except for the increased abundance of trough cross-stratification and upward-fining successions (Fig. 5D). The principal depositional systems are of mid- to distal-alluvial fan and braidplain origin. Channels in the upper member are predominantly bed-load, gravelly, horizontally stratified to trough cross-stratified with predominantly ribbon and minor sheet geometries. Scoured bases, cut-banks, and ribbon geometry suggest entrenchment of the fluvial system as the braided rivers tried to maintain gradient with a coarse bed load. Trough cross-stratification in this member indicates a north to northeasterly dispersal direction. Clast counts indicate that sedimentary-clasts were derived from Lower Cretaceous rocks and some Paleozoic formations.

In summary, the middle member deltaic environments were succeeded by flashy, high-energy, braided fluvial deposits of the upper member. The up-section change in composition is interpreted to have resulted from uplift along the southwestern margin of the basin, perhaps the Hidalgo uplift of Seager and Mack (1986). The basin was responding to thermal heating by the impinging magmatic arc (volcaniclastic deposits); therefore downcutting by the fluvial system into the sedimentary cover maintained a consistent dispersal direction from the middle to upper members.

During late Maastrichtian and early Paleocene time the Laramide arc migrated into southwestern New Mexico and created porphyry-copper deposits in southwestern New Mexico and Arizona (Lipman, 1980). The migration of the arc into southwestern New Mexico is represented by the increase in volcaniclastic deposits, including andesitic clasts and flows in the upper member of the Ringbone Formation, and the breccia deposits of the Hidalgo Formation that overlie and interfinger with the upper member of the Ringbone Formation on the northernmost block.

SANDSTONE PETROLOGY

Sandstone point-counts were performed to determine provenance of the Ringbone Formation. Point-counting parameters were defined by comparison of grain types observed in the Ringbone Formation with grain categories and types presented by Dickinson and Suczek (1979), Scholle (1979a, 1979b), McKenzie et al. (1982), and Adams et al. (1984). Thirty-nine sandstone beds were sampled from the Ringbone Formation (Basabilvazo, 1991).

Sandstones of the Ringbone Formation vary from fine- to very coarse-grained, angular to rounded, and poorly to moderately well sorted. The ternary plot positions of the Ringbone sandstones indicate that they are feldspathic litharenites, lithic arkoses, and litharenites. Sandstones from the lower and upper members typically plot in the recycled orogen field of the QmFLt plot and are litharenites (Fig. 6). Sandstones from the middle member plot in the magmatic arc field of Dickinson and Suczek (1979) and are typically feldspathic litharenites (Fig. 6). Interfingering of lithologically distinct sandstones of the lower and middle members and the middle and upper members accounts for the scatter in sandstone plot locations in Figure 6. Systematic compositional changes during the deposition of Ringbone strata permit confident member discrimination and correlation of members in the three geographic exposures.

CORRELATION

Ringbone strata of the three blocks in the Little Hatchet Mountains can be correlated using similar lithologic sequences and depositional environments observed in the three informal members on each block, identification of the air-fall tuffs on two blocks and the clustering of the sandstones from each member on the QmFLt ternary diagram. In addition, the recovery of dinosaur fossils from fine-grained material on each block provides qualitative correlation of the three exposures of Ringbone strata.

Similar lithologic sequences, stratigraphic relationships, depositional environments and dinosaur fossils also facilitate correlation of the Ringbone Formation to other Upper Cretaceous units in the geographic area. Upper Cretaceous units that correlate with the Ringbone Formation include the Fort Crittenden Formation of southeastern Arizona, the Amole Arkose of southeastern Arizona (Lawton et al., 1993), the Cabullona Group of southeastern Arizona and northern Mexico, and the McRae Formation of south-central New Mexico (Fig. 7).

SUMMARY

The Ringbone Formation in the Little Hatchet Mountains records early Laramide intermontane-basin development and synorogenic sedimentation in southwestern New Mexico. The Ringbone Formation comprises approximately 1600 m of nonmarine strata. Ringbone strata occur in three geographic localities separated by reverse faults in the Little Hatchet Mountains. Laterally continuous air-fall tuff horizons, similar stratigraphic evolution, close clustering of sandstones on ternary diagrams, and dinosaur remains permit correlation of the stratigraphic sections measured at these localities.

Three informal, lithostratigraphic members record transitions between fluvial and lacustrine environments in a tectonically active setting. Lacustrine and lacustrine-delta sedimentation was common, as evidenced by the thick sequences in the middle member. Albertosaur and hadrosaur remains indicate a late Campanian to Maastrichtian age for the middle member. The sedimentary-clast conglomerates in the lower and upper members were probably derived from an uplift located to the northeast. Feldspathic litharenites in the middle member were probably derived from the west and northwest by an axial-fluvial system. Interfingering of the upper member of the Ringbone Formation with the compositionally different Hidalgo Formation and the unconformable, stratigraphic relationship of the upper member of the Ringbone with the Skunk Ranch Formation supports the interpretation that the basin was undergoing partitioning in the Maastrichtian.

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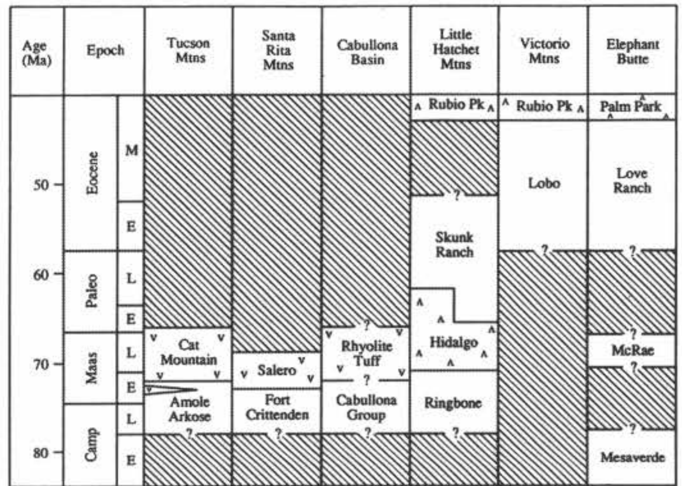

FIGURE 7. Correlation of Ringbone Formation in the Little Hatchet Mountains with strata of southeastern Arizona, northern Sonora Mexico, and south-central New Mexico. Modified from Lawton et al. (1993). Volcanic symbols: v, silicic volcanic unit; inverted v, intermediate volcanic unit.