NEW EVIDENCE FOR DEEPER WATER SITE OF LATE DEVONIAN ALAMO IMPACT, NEVADA.

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Introduction: The early Late Devonian (early Frasnian) Alamo Impact has been documented to have occurred in a marine setting [1–5]. Post-event geologic processes, however, have dismembered and buried the crater. Allochthonous and semi-autochthonous polymict breccias resulting from the marine impact are now exposed in nearly 20 mountain ranges in southern Nevada. They were emplaced in roughly semicircular belts of shoreward-thinning megabreccia and tsunamite deposits, designated Zones 1, 2, and 3, across the early Late Devonian carbonate platform and adjacent slope (Fig. 1). Recently, we found deeper water Alamo Breccia channel-fill deposits in a possible radial pattern [6], similar to that of an Ordovician oceanic impact in Sweden [7], in upper- to lower-slope settings, west of the shelf margin. Our new data corroborate the interpretation that the Alamo Impact occurred in an oceanic setting west of the carbonate platform margin.

Off-platform effects of Alamo Impact: Our new deeper water deposits are dated by conodonts as having been emplaced in the middle part of the *punctata* Zone, the same age as the Alamo Breccia, a member of the Guilmette Formation [2], on the carbonate platform. They are further identified by their unusual depositional fabric, heterolithic clast composition, and shock-altered quartz grains. The variable thickness of these discontinuous channel-fill deposits and their relation to enclosing slope rocks of various ages are depicted in a time-rock diagram (Fig. 2). At several of these sections, tapering, cm-scale clastic injection(?) dikes penetrate several meters below the breccia. Moreover, at Rawhide Mountain West (Fig. 2), the Alamo Breccia visibly downcuts and truncates underlying strata. These phenomena attest to its high-energy emplacement. The previously recognized regional downcutting by the Alamo Breccia across the carbonate platform [1] is now shown to continue seaward. This downcutting is illustrated by comparison of the dating of underlying deeper water Middle Devonian (late Givetian) deposits to the dating of the underlying carbonate-platform Guilmette Formation at Portuguese Mountain (Fig. 2). This most distal known, 1-m-thick outcrop of the Alamo Breccia, located ~100 km north of the inferred impact site [4, 6], was originally mapped by Chamberlain [8] and is now verified by us.

Possible impact-related phenomena: At Portuguese Mountain, the Alamo Breccia wedges out along strike into contorted autochthonous carbonate-platform rocks, which were possibly disrupted by seismic effects of the impact. Our mapping and sampling have identified several additional localities that may record effects of the Alamo Impact. These localities (Fig. 1), which are being studied further, include: (1) an anomalous, silicified breccia spire containing allochthonous clastic quartz grains, exposed in Sand Spring Valley (SS)

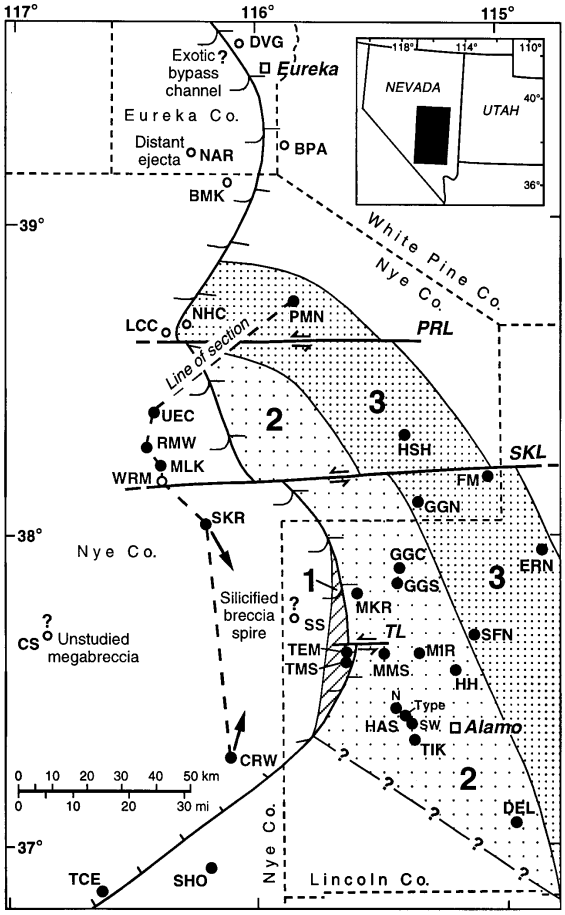

Figure 1 – Partly restored paleogeographic map contrasting areal distribution of Zones 1, 2, and 3 of Alamo Breccia, on and just off carbonate platform, with newly documented deeper water Breccia channel deposits farther west. Late Devonian (*punctata* Zone) carbonate-platform margin is shown by stylized, hachured line. Only Tertiary strike-slip lineaments affecting distribution of Alamo Breccia are shown: *PRL*, Pancake Range; *SKL*, Silver King; *TL*, Tempiute. Palinspastic reconstruction of post-depositional compressional and extensional faulting is not attempted. ●, AB localities; ○, other localities. New localities on line of section are named in Figure 2. Other discussed localities are identified only by initials. Arrows show suggested craterward directions of channels.

near the inferred impact site; (2) a very unusual Devonian(?) megabreccia exposed near Cactus Spring (CS); (3) shock-altered and studded quartz ejecta in *punctata* Zone beds, Northern Antelope Range (NAR); and (4) a previously reported, *punctata?* Zone channel-fill deposit at Devils Gate (DVG), composed of exotic, fine-grained lithic debris [2].

Conclusions: Our new data evidence the great magnitude and wide extent of the Alamo Event at offshore and distal localities. Resulting breccias are now recognized at least 100 km from the inferred impact site, and distal quartz ejecta, as distant as 170 km. We interpret offshore deposits of the Alamo Breccia to be large, submarine mass-flow channels or sheets that were emplaced both by high-energy, outward- and downslope-directed surge currents/tsunami originating at the Alamo Impact site and by inward-directed return currents backfilling the unstable transient crater. On the basis of our new evidence of large-scale, offshore effects, we conclude that the Alamo impactor struck a relatively deep water, oceanic target west of the early Late Devonian carbonate platform.

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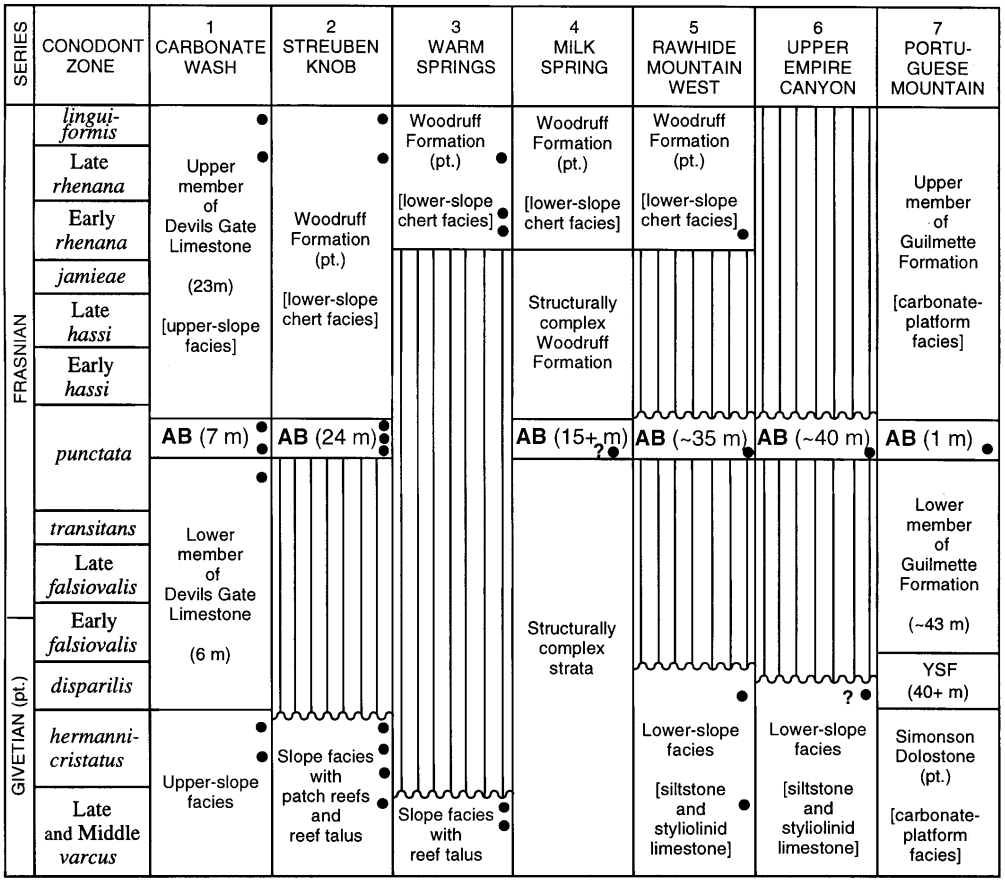

Figure 2 – Time-rock correlation chart of Alamo Breccia Member (AB) and enclosing stratigraphic units at seven recently documented sections in southeastern Nevada. See Figure 1 for locations. Mountain ranges in which sections are located: 1, Belted Range; 2, Reveille Range; 3, 4, 5, 6, southern Hot Creek Range; 7, Pancake Range. ●, conodont collection diagnostic of zone at left. YSF, yellow slope-forming unit that forms base of Guilmette Formation throughout Nevada and western Utah. At Upper Empire Canyon, Alamo Breccia is unconformably overlain by Mississippian Eleana Formation.