

**PROCESSES AND PRODUCTS OF THE MARINE ALAMO IMPACT EVENT, CENTRAL GREAT BASIN, WESTERN USA.** J. E. Warme<sup>1</sup>, J. R. Morrow<sup>2</sup>, and J. A. Pinto<sup>3</sup>, <sup>1</sup>Dept. of Geology and Geological Engineering, Colorado School of Mines, Golden, Colorado 80401, USA (jwarme@mines.edu), <sup>2</sup>Dept. of Geological Sciences, San Diego State University, 5500 Campanile Drive, San Diego, California 92182-1020, USA (jmorrows@geology.sdsu.edu), <sup>3</sup>INTEVEP-PDVSA, Building South 1, Floor 2, Office 202, 1201, Los Teques, Venezuela.

**Introduction:** Recent work has partitioned the distribution of the Alamo Breccia in southeastern Nevada and western Utah, western USA, into six genetic Realms (Fig. 1) that provide a working model for the early Late Devonian (~382 Ma), marine Alamo Impact Event [1]. Each Realm exhibits discrete impact processes and stratigraphic products (Table 1), which preserve an exceptionally well-exposed record of both proximal and distal marine impact phenomena. The first five Realms (Rim, Ring, Runup, Seismite, and Runoff) form roughly concentric semicircular bands onshore across the Devonian shallow-water carbonate platform. The sixth, the Runout/Resurge Realm, consists of offshore channels of thick, off-platform Alamo Breccia and large, crater-proximal olistoliths.

**Processes and Products:** (1) *Shock Waves:* Widespread evidence of the passing impact shock waves, including potentially the superimposed effects of Love, Rayleigh, and rarefaction components, is recorded in the platform Realms by large, tabular carbonate megaclasts and fluidized bedding and clasts. Other seismic-related features include (a) in the Ring Realm, a monomict, fluidized detachment surface defining the base of the Alamo Breccia (Unit D of past work); (b) in the Rim, Runout/Resurge, and Runup Realms, liquefied clastic injection dikes and sills; and (c) in the Runup and Seismite Realms, chaotic, strata-bound sequences. Because the pre-Alamo Event sedimentary-target sequence was dominated by early-cemented carbonates, fracturing, folding, and acoustic fluidization dominated over liquefaction, an important process recorded at other marine, sedimentary-target impact sites, e.g., Wetumpka [2] and Chesapeake Bay [3]. (2) *Other Shock Deformation:* These features include macroscopic, autochthonous to parautochthonous shatter cone-like structures documented in the Rim Realm [1] and widespread planar microstructure-bearing shocked quartz recovered from the Alamo Breccia in all Realms except the Seismite [e.g., 4, 5, 6]. (3) *Shock Melt:* Probable evidence for melt occurs as unusual, plastically deformed clasts and microscopic carbonate quench fabrics within interpreted fallback breccias (Units 3 and 4) in the Rim Realm at Tempiute Mountain (TEM, TMS, Fig. 1) [1], and as small, globular silicate grains disseminated within Alamo Breccia matrix [6]. (4) *Ejecta:* A wide variety of proximal and distal ejecta are preserved, including weak iridium

enrichment, shocked quartz grains, carbonate accretionary lapilli, rare accretionary “bombs”, target-rock lithic clasts, fallback breccias in the Rim Realm, and large megaclasts or olistoliths in the Runout/Resurge Realm [7] that may represent transported fragments of a crater-proximal “flap” [cf. 8]. (5) *Crater Modification:* These products, which are probably more widespread than currently recognized, include listric faults interpreted in the outer Ring Realm (DEL, Fig. 1), probable slump blocks in the Rim Realm (TEM, TMS, Fig. 1), and possibly the olistoliths described above. (6) *Marine-target Effects:* Offshore effects in the Runout/Resurge Realm consist of seafloor erosion and thick Alamo Breccia channel fill probably deposited during resurge flow into the crater [6]. In the Ring, Runup, and Runoff Realms, normally graded tsunamites [4, 5] and thin runoff channel deposits containing continent-sourced siliciclastic grains [6] are present. Microscopic fluid inclusion-rich “toasted” shocked quartz, possibly forming in response to a saturated marine target [9], is also widespread throughout the Alamo Breccia in all Realms but the Seismite.

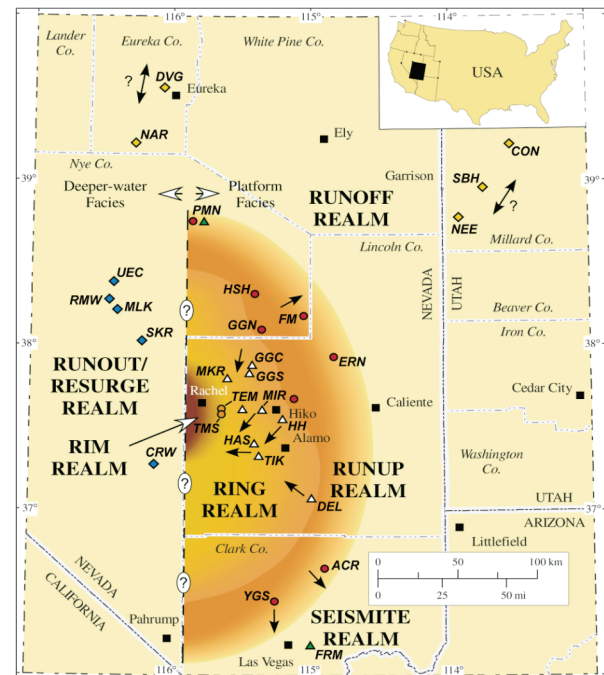


Figure 1. Tectonically unrestored distribution of six Alamo Breccia Realms, showing key localities (abbreviations). Arrows show paleocurrent directions. Modified from [1].

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Process	Product	Realm [1] (Fig. 1)	Representative Localities (Fig. 1)
<b>1) Surface Shock Waves</b> (Love, Rayleigh, rarefaction)	Proximal:		
	Tabular mega-clasts; fluidized bedding and clasts	Rim; Ring	TEM, TMS; DEL, HAS, HH, MIR, TIK
	Liquified clastic injection sills and dikes	Rim; Runout/ Resurge; Runup	TEM, TMS; UEC; PMN
	Distal:		
	Seismites	Seismite	FRM
	Fluidized bedding	Runoff; Seismite	DVG, SBH; FRM
<b>2) Shock Deformation</b>	Megascopic: (autochthonous)	Rim	TEM, TMS
	Microscopic: (allochthonous)	All except Seismite	CON, DVG, FM, HAS, HH, MLK, PMN, TEM, TMS
<b>3) Shock Melt</b>	Carbonate:	Rim	TEM, TMS
	Silicate:	Rim; Ring; Runoff; Runout/Resurge	TEM, TMS; HAS, MIR, TIK; CON; MLK
<b>4) Ejecta</b>	Proximal:		
	Lapilli and lapillistone	Rim; Ring	TEM; HAS, MIR, HH, TIK
	“Bombs”	Ring; Runout/Resurge	HH; MLK
	Target-rock clasts	Rim; Ring; Runout/Resurge; Runup	TEM, TMS; HAS, TIK; MLK, SKR; FM, PMN
	Fallback breccias, Units 3 and 4, Tempiute Mountain	Rim	TEM, TMS
	Olistoliths or “flap” remnants(?)	Runout/Resurge	MLK
	Proximal and distal:		
	Shocked quartz grains	All except Seismite	DVG, FM, HAS, HH, MLK, NAR, PMN, TEM, TMS
Weak iridium anomaly	Ring; Runoff	MKR; CON, DVG	
<b>5) Crater Modification</b>	Listric faults	Ring	DEL
	Rim-proximal slump blocks, Unit 3 fallback breccia, Tempiute Mountain	Rim	TEM, TMS
	Olistoliths or “flap” remnants(?)	Runout/Resurge	MLK
<b>6) Marine-target Effects</b>	Seafloor erosion	Runout/Resurge	MLK, SKR
	Tsunamiites	Ring; Runup; Runoff(?)	HAS, HH, MIR; ERN, FM; CON, DVG
	Resurge channel deposits	Runout/Resurge	MLK, SKR, UEC
	Onshore runoff channel deposits	Runoff	CON, DVG, SBH
	“Toasted” shocked quartz grains	All except Seismite	DVG, FM, HAS, HH, MIR, MLK, PMN, TEM, TIK

Table 1. Impact processes, resulting products, and positions within genetic Realms of the Alamo Impact Event.