3-D SEISMIC AND WELL LOG ANALYSES OF THE VICTORIA ISLAND STRUCTURE, A POTENTIAL BURIED IMPACT CRATER, SAN JOAQUIN COUNTY, CALIFORNIA

S. C. Spevack[1], J. R. Morrow[2], and B. Z. Spevack[3]

[1]Grossmont Middle College High School, El Cajon, CA 92020, [2]Dept. of Geological Sciences, San Diego State University, San Diego, CA 92182-1020, [3]ABA Energy Corporation, Bakersfield, CA 93308

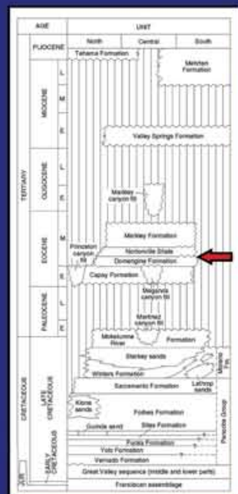

Figure 1 — Locality map and stratigraphic column for Victoria Island structure. Approximate stratigraphic position of the top of the structure, located within middle Eocene upper Domengine Formation, is indicated by red arrow. Structure is centered at ~N 37°53', W 121°32'. Stratigraphic column modified from [6].

Introduction: Analyses of a 3-D seismic survey and well logs in the southwestern Sacramento basin, San Joaquin County, California (**Fig. 1**), have revealed a subsurface, circular, ~5.5-km-diameter anomaly that may represent a previously unrecognized complex impact crater. This unique anomaly, buried ~1,490–1,600 m below sea level under the southwestern part of the Sacramento-San Joaquin Delta, is provisionally named the Victoria Island structure for an overlying surface geographic feature.

Description: The Victoria Island structure is characterized by a concentric, annular, terraced rim and trough surrounding a structurally uplifted central peak (**Figs. 2–4**). Well logs tied to seismic data show that the upper surface of the structure occurs stratigraphically near the top of the siliciclastic, continental to shallow-marine Domengine Formation, indicating a middle Eocene age (**Figs. 1, 5**) [1]. Overlying fill material, which reaches an estimated thickness of at least 80 m in the trough, is primarily deep-marine, middle Eocene Nortonville Shale. Both well and seismic data indicate thinned Domengine and thickened Nortonville sections across the feature center (**Figs. 2–5**).

A disturbed stratigraphic sequence under the structure includes upper to lower Domengine and underlying lower Eocene Capay Formation and Cretaceous-Paleocene Mokelumne River Formation siliciclastic units. Characterized by discontinuous seismic reflectors (**Fig. 3**), the central peak is estimated to be ~600 m in diameter with at least 35 m of structural uplift. The seismic data demonstrate that the feature is 'rootless', being underlain by gently dipping, relatively undeformed strata (**Fig. 3**). The 3-D data further suggest the presence of a series of discontinuous, inward-dipping, concentric normal faults with minor offset surrounding the trough and outer rim areas (**Figs. 3, 6**). Estimates of the dimensions of the structure indicate a circularity ratio (short-to-long axes) of 0.91 and a depth-to-diameter ratio of ~0.02.

Ongoing Work: The observations above, including the seismic expression, complex morphology with central uplift, high circularity, depth-to-diameter ratio, and anomalous setting of the structure, are most consistent with documented, diagnostic characteristics of impact craters [2–4]. Ongoing petrographic work is examining drill cuttings from wells within and around the structure, to seek such additional impact indicators as an impactite layer, shocked mineral grains (**Fig. 7**), glass fragments, or melt particles, and to assess the feasibility of future geochemical analyses of the structure. Supplemental cuttings and well log data may also further constrain the stratigraphic age of the structure within the Domengine-Nortonville interval. Together with the previously proposed, 1.3-km-diameter, Miocene-age Cowell structure [5], the Victoria Island structure represents the second potential buried impact crater from California's Central Valley region.

References: [1] Sullivan M. D. et al. (2003) *Pac. Sec. SEPM Guidebook 94*, 51 p. [2] Melosh H. J. (1989) *Impact cratering, a geological process, Oxford Univ. Press*, 245 p. [3] Therriault A. M. et al. (2002) *Bull. Czech Geol. Survey 77(4)*, 253–263. [4] Stewart S. A. (2003) *Geology 31(11)*, 929–932. [5] Blake R. G. (1998) *AAPG Bull. 82(5A)*, 842. [6] Magoon L. B., III, and Valin Z. C., Sacramento Basin (009), *U.S. Geological Survey Digital Data Series DDS-30, Release 2*, CD-ROM (accessed Feb. 23, 2007).

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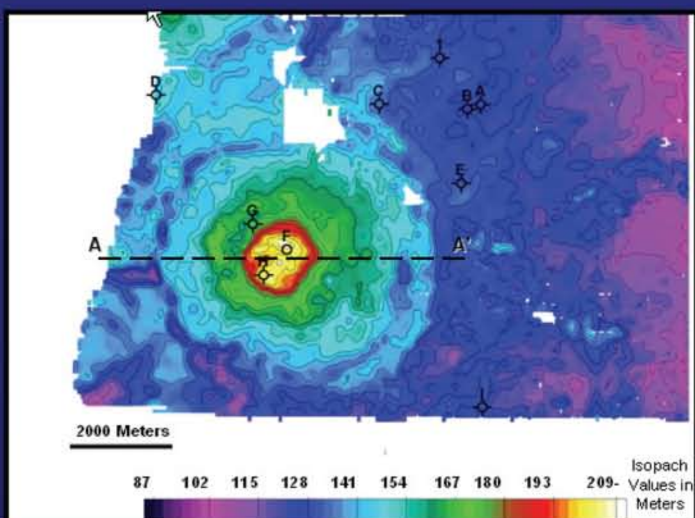


Figure 2 (left) — Isopach map of potential crater infill, between upper Nortonville Shale marker (blue line, Fig. 3) and base Nortonville Shale/top Domengine Formation marker (red line, Fig. 3). Colored isopach scale is in meters. West-to-east seismic profile line A–A' (Fig. 3) is indicated; other letters correspond to well locations.

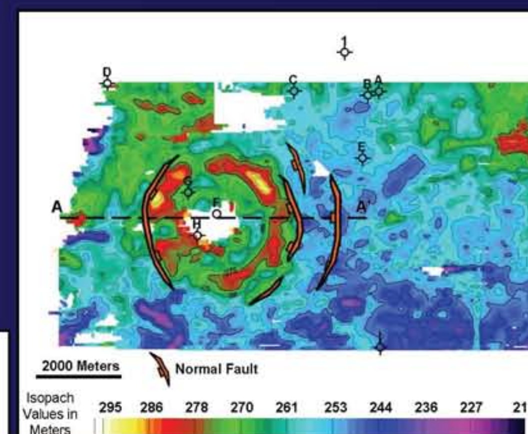


Figure 6 (right) — Isopach map of interval between upper Nortonville Shale marker (blue line, Fig. 3) and lower Domengine Formation marker (green line, Fig. 3), showing series of concentric circular ridges and troughs, together with positions of several major, curvilinear normal faults that surround the structure and cut the lower part of the isopached interval. Colored isopach scale is in meters. West-to-east seismic profile line A–A' (Fig. 3) is indicated; other letters correspond to well locations.

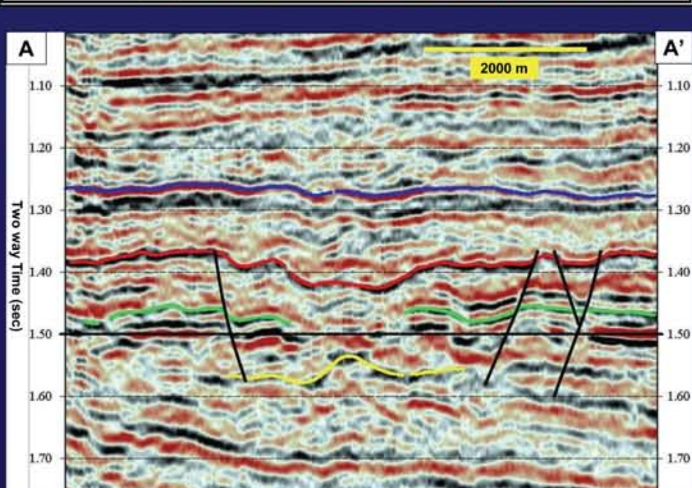


Figure 3 — West-east seismic profile across structure (A–A', Fig. 2). Stratigraphic markers: Blue– upper Nortonville Shale; red– base of Nortonville Shale/top of Domengine Formation; green– lower Domengine Formation; yellow– approximate base of Capay Formation/top of Mokelumne River Formation. Selected major, concentric normal faults (Fig. 6) that intersect the profile are shown schematically by black lines.

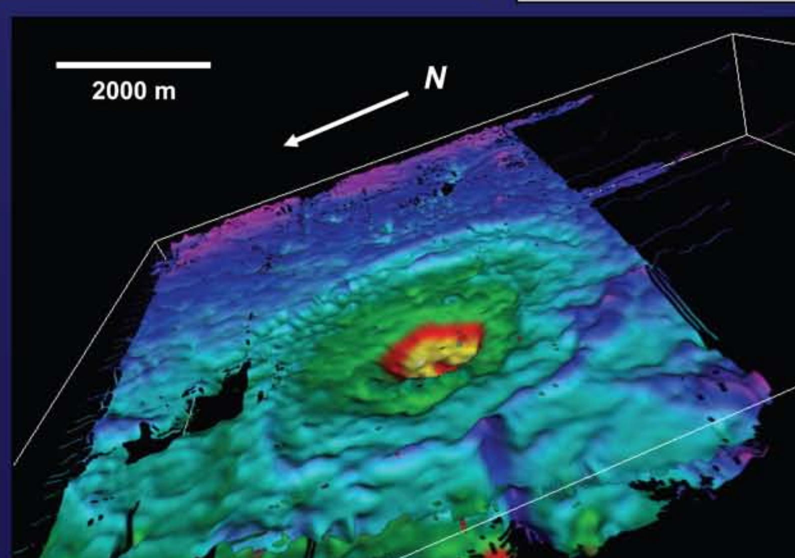


Figure 4 — Oblique, inverted 3-D-view isopach map of potential crater infill. Map is based on same isopach interval as in Figure 2, between upper Nortonville Shale and base Nortonville Shale/top Domengine Formation markers. Vertical exaggeration is 20X. Isopach colors and thicknesses are same as in Figure 2. Note north arrow.

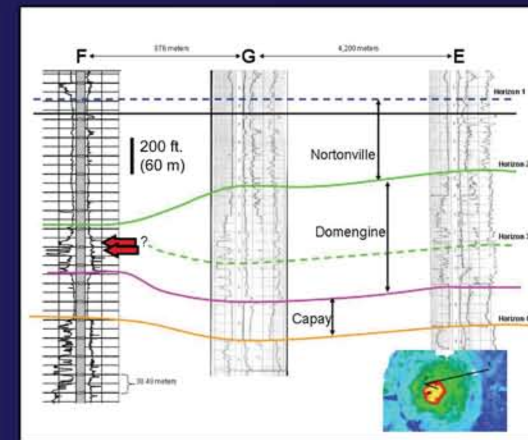
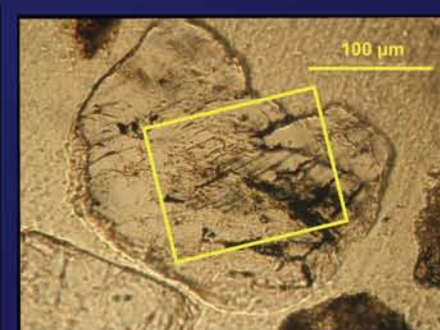
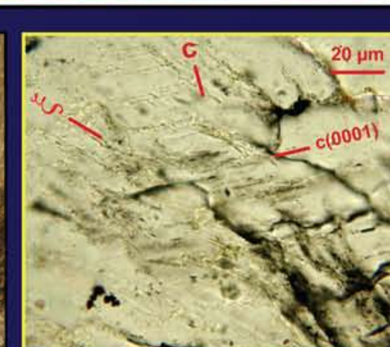


Figure 5 – Stratigraphic correlation, based on interpreted electric well logs (spontaneous potential, left curve; resistivity, right curve), from center to outer rim of structure. Red arrows mark well cutting sample intervals with quartz grains shown in Figure 7. Location of wells shown on inset (see also Fig. 2). Well logs are hung on upper Nortonville Shale datum.





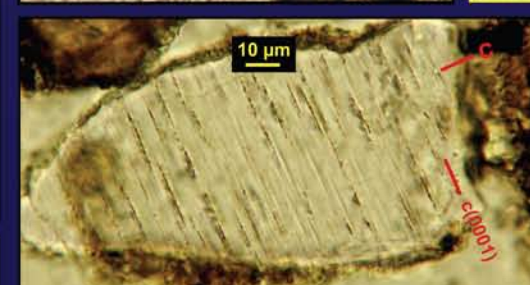


Figure 7 – Planar microstructures in quartz from well cuttings at a drilling depth of 5380-5440 ft. (1630-1650 m), well 'F' (Fig. 5), center of Victoria Island structure. Grain shown at upper left and above (see inset) contains four sets of poorly to moderately developed planes; only two are indicated on inset. Second grain shown at lower left contains one prominent set of c(0001) planes. C-axes are also marked. Planar microstructures, which are present in <1 vol. % of quartz grains from this interval, have basal (c(0001)) and high-index orientations typical for planes in shocked quartz from previously documented sedimentary-target impacts.