FURTHER GEOPHYSICAL DATA IN THE SEARCH FOR THE AUSTRALASIAN TEKTITE SOURCE CRATER LOCATION IN THE SONG HONG - YINGGEHAI BASIN, GULF OF TONKIN.

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Introduction: In 2013 an abstract was published [1] outlining the strong circumstantial evidence that the Australasian tektite source crater lies in the Song Hong – Yinggehai (SHY) Basin, Gulf of Tonkin. This abstract provides an update of available data.

Expectations: A crater of around 40 km diameter [2] is anticipated, possibly nested in a larger shallow outer crater [3]. Collapse & slumping of soft sediments might be expected. Distal ejecta demonstrates a highly oblique impact (under 20°); however, the crater would be expected to be (close to) circular, possibly slightly elongated along a NW-SE axis [4]. A peak ring (around one third of the crater diameter) and / or central uplift peak that is offset to the NW is expected. The profile of the crater will be asymmetrical, being deeper and with more pronounced margins to the NW [3, 4]. A raised rim and overturned beds may be absent due to surgeback effects during implosion of the transient water cavity [5]. In the SHY Basin one might expect the crater to be entirely buried by 250+ meters of sediment. Potentially comparable structures include Chesapeake Bay, Mjølinor and Montagnais Craters.

Evidence of a source crater in the SHY Basin: Note that some of this section was expanded in [1].

Tektitic evidence: a) Microtektite regression [6, 7]; b) Macro-tektite and layered impact glass distribution [1]; c) The regression of tektite localities – expanded in [8]; d) ^{10}Be iso-concentration [9]; e) High ^{10}Be concentration that demand the source rock must be young in age (with the inference that tektites are poorly mixed) [10]. A conflicting Rb-Sr age [11] likely represents averaged source rock age with the Rb-Sr clock not being reset due to rapid deposition. The crater must therefore lie a thick sequence of rapidly deposited Plio-Pleistocene sediment in a location compatible with the aforementioned regression data. Based on the above criteria, the crater lies in the central to western portion of the Gulf of Tonkin, with areas close to the depo-center of the SHY Basin being optimal in terms of sediment thickness and clastic content.

Regional geological evidence: f) Absence of a crater or crater lake on land. Complete erosion of the crater from land in c. 788 ka is highly improbable. Erosion rates in the east coast of Vietnam are estimated at 390-500 m/Myr [12] and in north Vietnam 100 ± 20 m/Myr to 127 ± 25 m/Myr [13]. Complete burial in the SHY Basin is easily attainable; g) Shale diapir arrangement, after [14, 15], may be related to concentric compressional ridges or faulting from impact; h) Possible annular negative gravity anomalies consistent with an annular trough surrounding a peak ring; i) Possible seismic data (limited public data in [14, 15]); j) Sediment isopach maps with areas of chaotic seismic reflection [13, 16]; k) Electronic and mud log offset well data indicating ejecta thickness (no public data).

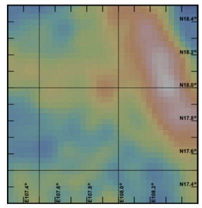
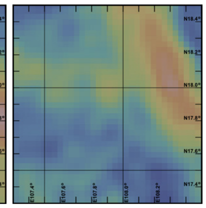
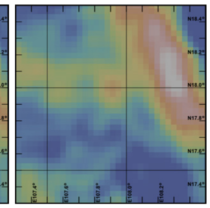




Fig. 1: (Left) Lower resolution Bouguer anomalies. **Fig. 2:** (Middle) Free-air anomalies. **Fig. 3:** (Right) Isostatic anomalies. Source: WGM2012 from GeoMapApp (http://www.geomapapp.org).

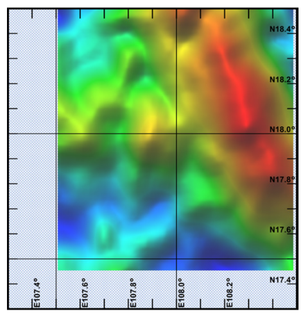
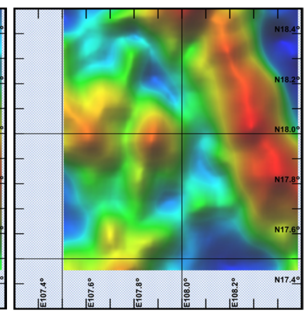



Fig. 4: (Left) Medium resolution free air gravity. **Fig. 5:** (Right) 100 km high pass free air gravity. Data provided by GETECH in 2012.

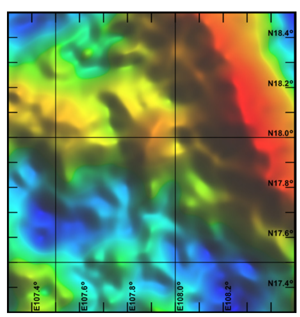
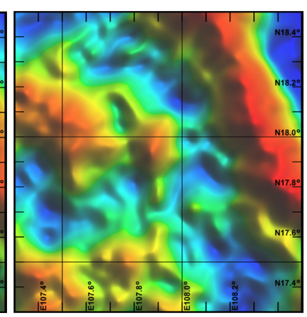
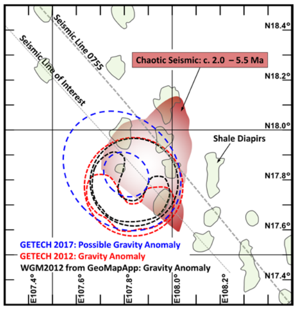



Fig. 6: (Left) Higher resolution free air gravity. **Fig. 7:** (Right) 100 km high pass free air gravity. Data provided by GETECH in 2017.

Discussion: Low and medium resolution gravity data from 2012 (Fig. 1-5) hints at a c. 44 km diameter possible circular / annular feature centered on E107.85°, N17.78° in the area expected and of a size consistent with the expected source crater. Newly acquired (2017) higher resolution gravity data [17] shows less prominent features (Fig. 6-7). With an eye of faith, one might make out a speculative c. 57 x 47 km feature (ellipticity of 1.2) with c. 18 x 21 km inner ring centered on E107.81°, N17.82° (Fig. 8).



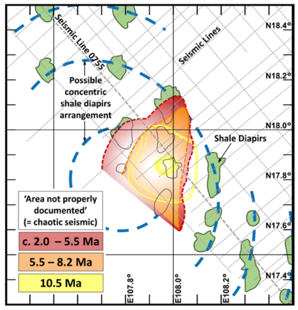


Fig. 8: (Left) Overlain positions of observed gravity anomalies in Fig. 1-7 relative to shale diapirs [15] and chaotic seismic [16]. See note below on positioning being approximate. **Fig. 9:** (Right) 'Areas not properly documented' on seismic. Chaotic seismic reflection at three stratigraphic levels, after [16], repeated in [14]. Shale diapirs and seismic lines after [15].

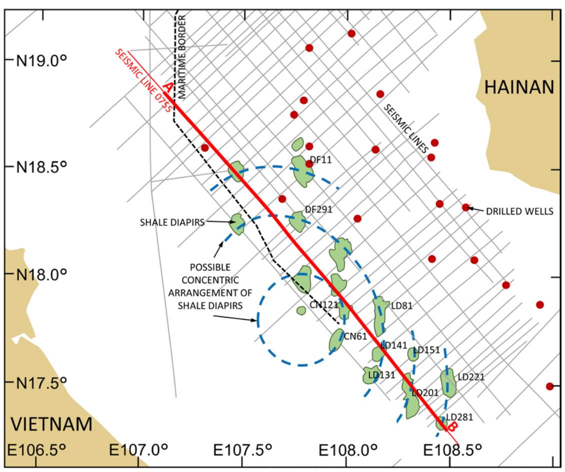


Fig. 10: Approximate position of seismic lines including line 0755 (red), interpreted shale diapirs and location of drilled wells, after [15].

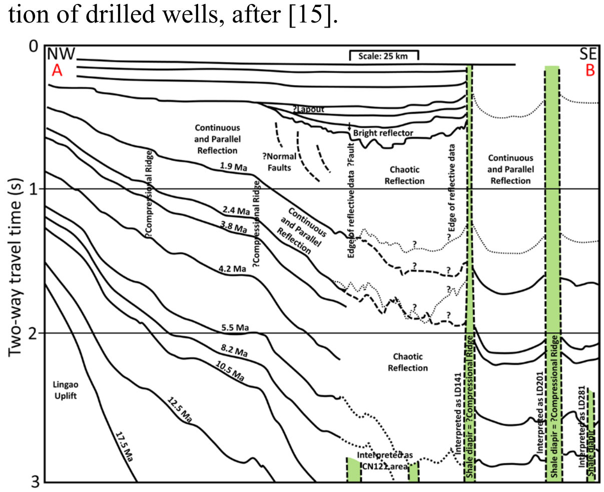


Fig. 11: A modified review of seismic line 0755 (after [15], vertically exaggerated). Refer to [15] for original data. Approximately 2 km depth of sediment is shown.

Available seismic data is sub-optimal in terms of resolution and positioning. Nonetheless, line 0755 (Fig. 10 & 11), viewable in [15], confirms the presence of chaotic reflection, has possible faulting of consistent magnitude to that seen in the outer rim of Chesapeake Bay Crater [5], and exhibits possible lapout at a level consistent with 0.788 Ma. Thrust faults are noted near LD81 [18]. High angle layer-bound faults in [14]. An area of uncertainty, caused by chaotic seismic reflection to the late Miocene level was noted in [16] and repeated in [14] (Fig. 9). These features are consistent with an impact crater, but may have other origins.

Recommendations: Further seismic data should be reviewed. The parallel line to the SW of line 0755 in Fig. 8 would be ideal for further evaluating the crater hypothesis. No wells have been drilled over the gravity anomaly. The 2017 gravity data presented herein is more subtle in features, but remains consistent. The 'overlain' circumstantial evidence seems more than coincidental and should warrant further investigation.

Note: Shoreline and / or grid line positioning and scales often appear to have a low degree of accuracy in the available literature. This leads to a c. 12 (-20) km x-y uncertainty in precise positioning of seismic lines and features such as diapirs and chaotic sediment. Gravity data presented herein is accurately located.

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References: [1] Whymark A. (2013) *LPS XLIV*, Abstract #1077. [2] Glass B. P. (2003) *LPS XXXIV*, Abstract #1092. [3] Ormö J. et al. (2013) *Meteoritics & Planet. Sci., 48 (3),* 403-419. [4] Gault D. E. and Wedekind J. A. (1978) *LPS IX*, 3843-3875. [5] Poag C. W. 2005. *Geol. Soc. Am. Sp. Paper 384*, 117-130. [6] Glass B. P. and Koeberl C. (2006) *Meteoritics & Planet. Sci., 41 (2),* 305-326. [7] Prasad M. S. et al. (2007) *J. Geophys. Res., 112, (E6)*. [8] Whymark A. (2016) *LPS XLVII,* Abstract #1073. [9] Ma P. et al. (2004) *Geochim. Cosmochim. Acta, 68,* 3883-3896. [10] Pal D. K. et al. (1982) *Science, 218 (4574)*, 787-789. [11] Blum J. D. et al. (1992) *Geochim. Cosmochim. Acta, 56 (1),* 483–492. [12] Carter A. et al. (2000) *Tectonophysics, 322,* 265-277. [13] Yan Y. et al. (2011) *Geochem. Geophys. Geosyst., 12 (6),* Q06014. [14] Lei C. et al. (2011) *Mar. Petrol. Geol., 28*, 980-991. [15] Lei C. et al. (2015) *Tectonophysics, 655,* 177- 190. [16] Gong Z. and Li S. (1997) *Continental Margin Basin Analysis and Hydrocarbon Accumulation of the Northern South China Sea. Science Press, Beijing,* 510 pp. [17] Fletcher K. et al. (2016) *AAPG Datapages / Search and Discovery Article #90259, AAPG Annual Convention and Exhibition, Calgary, Alberta, Canada, June 19-22, 2016.* [18] Yin et al. (2004) *J. China Univ. Geosci., 15 (2),* 238-244.