**CRATER-FLOOR EXHALATIVE (CRAFEX) SULFIDE DEPOSITS AT THE CHICXULUB CRATER, YUCATÁN, MÉXICO.** A.R. Hildebrand1 and M. Pilkington2, 1Department of Geology and Geophysics, 2500 University Drive NW, Calgary, AB T2N 1N4 (hildebra@geo.ucalgary.ca), 2Continental Geosciences Division, 615 Booth Street, Ottawa, ON K1A 0E9 (mpilking@NRCan.gc.ca).

**Introduction:** It is now axiomatic that exploration of the Chicxulub crater, Yucatán Peninsula will shed light on impact induced environmental perturbations and on the structure of large craters. The crater also has practical consequences in controlling groundwater flow in Yucatán state and in producing proximal deposits that produce hydrocarbons. Additionally, seismic and aeromagnetic data indicate that crater-floor exhalative deposits exist on the crater floor at potentially economic depths of ~1.1 km. We suggest that these exhalative deposits may contain metallic sulfide deposits analogous to those found on the Sudbury crater floor, and that a new type of exhalative sulfide deposit be recognized, the crafex category (crater-floor exhalative) [1].

**The crafex deposit model:** The Chicxulub crater retained roughly half of the ~1.0 X 10^31 ergs released by the impact in its heated and brecciated rocks. Much of the melt rock formed a continuous pool of 1.5 to 3.0 km thickness (10,000 to 20,000 km^3 volume) within the collapsed disruption cavity (CDC) [e.g. 2, 3]. An additional source of heat is the shock heated and uplifted rocks of the central uplift which may contain a quantity of energy comparable to that found in the impact melt. This heat will have been dissipated primarily by hydrothermal systems into the approximately 1 km-deep seawater basin that initially filled Chicxulub. Thus, the ~90 km diameter CDC formed a cooling system analogous to an active rift or island arc system, but probably with proportionally greater quantities of heat deposited at shallow depths. Two stages of cooling are envisaged: vigorous convection driven by the crystallizing melt pool of 10,000 to 100,000 years duration, followed by continuing convection driven by the cooling of the hot rocks of the melt pool and central uplift of 100,000 to 1,000,000 years duration. As in any hydrothermal setting, fluid flow is expected to be concentrated along fracture systems induced by faults as also happened at the Sudbury crater [4]. Large craters show characteristic patterns of radial and concentric faults [e.g., 5] which at Chicxulub are expected to lie within ~45 km of the crater centre. Figure 1 shows mounds on the Chicxulub crater floor as imaged by an offshore seismic line [e.g., 6] which are apparently rooted by vertical zones of distinct seismic character. We interpret these mounds to be of exhalative origin - the largest is ~250 m high and ~2.2 km-wide in this cross section. Extrapolating from the number of mounds imaged by offshore seismic at Chicxulub to date (and the two exhalative deposits known at the Sudbury), a population of 50 ± 20 exhalative mounds (of 0.7 to 2.2 km diameter) is predicted overlying the CDC. Based on the mineralogy of the deposits preserved on the Sudbury crater floor, the sulfide minerals of economic interest are expected to contain Zn-Cu-Pb (-Ag-Au), occurring as replacements of carbonate mound material [e.g., 7].

**Aeromagnetic survey results:** A commercial aeromagnetic survey at 0.5 km line spacing was flown over a part of the Chicxulub crater in 1997 revealing the details of the three concentric zones of magnetic expression as previously defined [2, 8]. (See Figure 2.) However, new anomalies of <5 km diameter were found, and boundaries of some pre-existing anomalies were substantially revised. The survey revealed many short-wavelength linear anomalies over the CDC, with both concentric and radial orientations. In the southwest, and to a lesser extent in the southeast, a concentric pattern of three linear dipolar anomalies occurs at the outer edge of the second zone. The innermost feature is of large amplitude (~200 nT) and corresponds to the large gravity gradient feature that outlines the collapsed disruption cavity. The other two dipolar anomalies decline in magnitude outwards, ~60 nT and ~20 nT, respectively. Their structural control is a subject of speculation.

**Magnetic-field modelling:** The source body geometries for the surveyed area were explored with Euler deconvolution, pseudogravity gradient, and analytical signal analysis before 2-D forward modelling along selected profiles. As found previously [2, 8], all the new anomalies indicate reversed polarities from remnant-dominated source bodies. Almost all the large-amplitude, short-wavelength anomalies apparently represent relatively narrow sources of 1 to 5 km width. Chicxulub’s melt sheet is criss-crossed by narrow (generally 1 to 2 km-wide), strongly magnetic zones with mostly steep dips.
Fracture-controlled hydrothermal systems: The narrow highly magnetic zones (3 - 7 A/m) are interpreted to represent volumes of melt rock that were strongly altered by the hydrothermal systems associated with melt sheet cooling. Discordant zones of intense alteration underlie the exhalative deposits in the Sudbury crater [e.g., 7]. Any alteration of Fe-bearing minerals has the potential to produce magnetite at appropriate oxygen fugacities [e.g., 9]. As the large magnetizations modelled at Chicxulub require strongly magnetized volumes of rock, a plausible scenario is that intense hydrothermally driven chlortization or epidotization of the melt sheet augites produced magnetite along fracture fault systems during crystallization and/or cooling of the melt sheet. These zones are predicted to root exhalative mounds on the crater floor as imaged seismically in Figure 1.

Chicxulub crater’s economic potential: Applying the method of [10] to estimate sulfide tonnages that might be produced by crystallizing/cooling Chicxulub melt volumes of 10,000 and 20,000 km³, and using a range of model parameter values, yields 230 - 2,000 X 10⁶ tonnes of sulfides. Assuming 50 sizeable mounds/deposits on Chicxulub’s crater floor yields average sizes of 4.5 to 40 X 10⁶ tonnes; assuming a log normal distribution for the deposits indicates that the largest deposits will equal or exceed 50 X 10⁶ tonnes. Although the CSDP well at Yaxcopoil-1 is outside Chicxulub’s CDC, the basal Tertiary stratigraphy may still record the predicted hydrothermal halo (e.g. Mn, Fe, Ba, Ni, Re, Pd, Co, Cr, Cu, Zn, Pb, V, S and As) associated with the crafex deposits.

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Figure 1: Seismic reflection image of mounds (A, B, C, D) interpreted to be of exhalative origin on offshore line A of the 1996 BIRPS-Imperial College survey [e.g., 7]. The short bright reflectors indicated by E underneath the largest mound, and the overlying low reflectivity zone are thought to represent the hydrothermal feeder system "rooting" the mounds. F indicates subhorizontal discontinuous reflectors of unknown significance at ~3s TWTT that occur across the centre of the crater. G and H exemplify a series of ~30° dipping reflectors across Chicxulub’s CDC that may represent late-stage thrusting induced by isostatic buckling or thermal contraction.

Fig. 2: 3-D plot of the total magnetic field over the Chicxulub crater viewed in perspective looking towards the northwest. This plot merges a 1997 detailed survey with the 1978 regional survey results of Petróleos Mexicanos. Note roughly 90 km-diameter subcircular zone of large amplitude anomalies that corresponds to the CDC filling at Chicxulub. Long wavelength anomalies interpreted as representing regional basement can also be seen.