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Ice Scour Risk and Protection on the Grand Banks

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ABSTRACT

Hydrocarbons were first discovered offshore Newfoundland in the late 1970s and full-scale production of these discoveries began in earnest in 1997 with the Hibernia oil field. The estimated total recoverable oil reserves on the Grand Banks are currently around 2100 MMbbls (million barrels), with additional potential reserves of more than 3000 MMbbls. In addition, there is estimated to be as much as 6800 BCF (billion cubic feet) in natural gas reserves with an additional 4000 BCF located on the Labrador shelf [1].

Most current and planned oil field developments on the Grand Banks consist of subsea completions involving wellheads, manifolds, flow lines and risers. This method of subsea production is becoming increasingly popular in harsh environments (such as the Norwegian and Barents Sea) as well as for the economic development of marginal fields. The prevalence of icebergs off the coast of Newfoundland and Labrador represents a significant risk of damage to these subsea completions and this risk must be mitigated to an acceptable level for the technologies to be safely utilized. The most successful mitigation has been the implementation of excavated drill centres, EDCs (formerly known as glory holes).

The following paper will provide a brief description of the environmental threats present in ice environments, a description of past projects, and the challenges inherent with creating the EDCs on the Grand Banks.

1 INTRODUCTION

The Grand Banks of Newfoundland are a series of shallow plateaus, ranging in depth from 20 – 100 m, extending off Newfoundland's south-eastern coast. Exploration in this area began around the same time as it did in the North Sea and despite similar operation and construction issues a similar level of momentum was never achieved (Figure 1). This can be largely attributed to the Grand Banks' harsher environment, specifically the presence of sea ice and icebergs, which require additional design consideration to ensure the protection of personnel, environment and infrastructure [2].

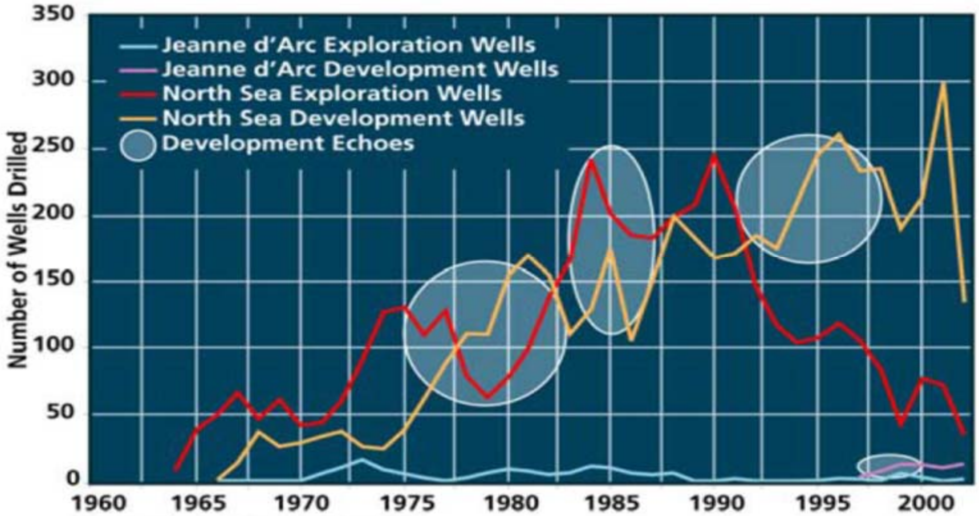

Figure 1: Exploration and Development – North Sea versus Newfoundland [2]

With production on the Grand Banks underway most future developments scenarios can be expected to include some form of subsea completion. This type of development is becoming increasingly popular, in the North Sea as well as in other oil producing regions, as it reduces the development cost. This could make the difference for developing many marginal fields on Canada's East Coast, if sea ice incursion can be properly addressed and mitigated [3].

2 ICEBERG SCOUR RISK

The number of icebergs which may enter the Grand Banks in a given year has been estimated to be around 800, the majority of which originate from the west Greenland glaciers. When icebergs finally reach the Grand Banks of Newfoundland they drift either eastward, north of the Flemish Cap, or southward between the Flemish Cap and the Grand Banks which is often referred to as "Iceberg Alley" (Figure 2) [4]. These icebergs can drift onto the Grand Banks and pose significant risk to production and drilling operations.

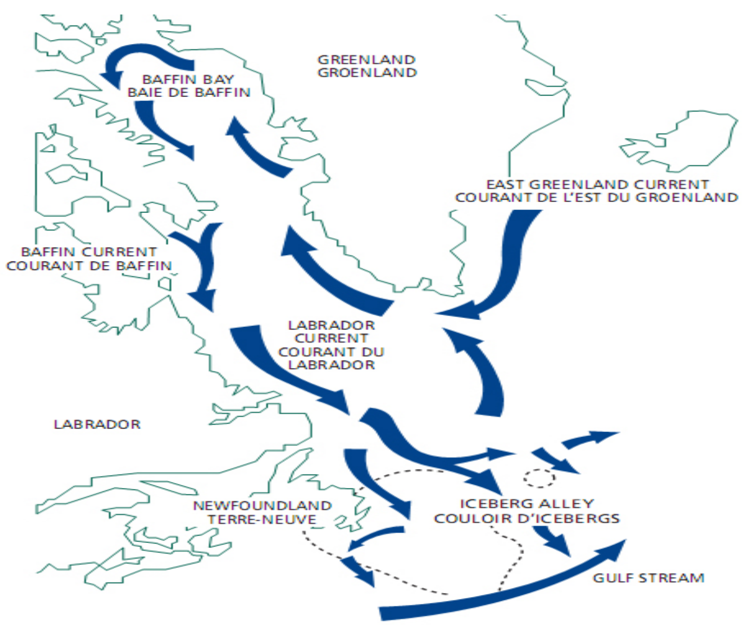

Figure 2: Eastern Canada Iceberg Trajectories [4]

Current design standards fail to define to level of reliability or safety targets for installing equipment in arctic and sub-arctic environments, however the Canadian Standards Association offshore codes do provide some form of guidance. S471-04, which has since been integrated into the ISO standard for Arctic offshore structures 19906:2010, defines two reliability levels for the safety of a structure which are dependent of the consequences of structural failure [5]. The description of the safety classes is shown in Table 1

Table 1: CSA Target Safety Levels

Safety Classes	Consequences of Failure	Target Annual Reliability Level
Safety Class 1	Great risk to life or high potential for environmental pollution or damage	10^{-5}
Safety Class 2	Small risk to life and low potential for environmental pollution or damage	10^{-3}

Based on the consequences, subsea equipment should be considered Safety Class 1 because of the high environmental damage that would be caused by failure; however in reality, a Class 1 event would only exist if a valve were to be damaged and the ability to shut out the well was lost. Croasdale et al.[6] performed a study of iceberg risk to Grand Banks installations, and showed that by lowering the vertical height of subsea equipment it is possible to reduce the annual contact probability to 10^{-4}. Relative to the lowered height of the equipment, ice scours are shallow and unlikely to be severe enough to damage the protected valves. It is therefore reasonable to consider equipment that is protected within an excavated drill center (EDC) sufficiently safe to be operated on the Grand Banks.

Figure 3: Potential Protection Afforded by EDCs

2.1 EDCs

Open EDCs, or glory holes as they were formerly known, where first proposed as a means of protection for the shallow water drilling in the Beaufort Sea. As the name suggests, EDCs are large excavations into the seabed which provide protection for subsea equipment. Typically they are nine to ten meters deep, which provides sufficient clearance from the mudline to the top of any equipment [7]. Figure 4 provides a profile view of a typical EDC.

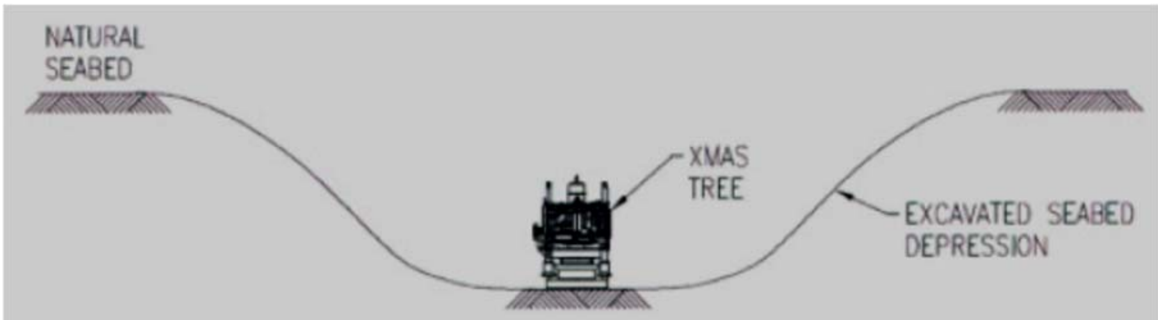

Figure 4: Typical EDC Profile

3 IMPLEMENTATION ON THE GRAND BANKS

To date there have been six attempts at creating excavated drill centres on the Grand Banks, two by PetroCanada/Suncor, three by Husky Energy and most recently by Hibernia Management and Development Company (HMDC). This brief examination of existing EDCs will focus on those created for the Terra Nova and White Rose fields.

3.1 Existing EDCs

In 1998, PetroCanada began its first attempt at creating an EDC using the *Sea Sorceress* to drill four large holes into the seabed. The system used a ‘DeBeers diamond mining’ drill that would attempt to apply torque to the seabed. Ultimately, this design failed because it could not operate in the North Atlantic sea states and could not cut through the hardpan on the seafloor.

For the next season the *Sea Sorceress* was replaced by a Trenching Suction Hopper Dredger (TSHD), the *Queen of the Netherlands*. The TSHD used an excavation process in which a 6.5 meter wide draghead was dragged across the seabed. The draghead was designed to break up the seabed material so it could be drawn up the internal suction tube and into the ship’s hopper. Water jetting was also used periodically to assist in the break-up of materials. The *Queen of the Netherlands* was able to complete all five of its scheduled drill centres without experiencing any significant delays and was largely considered a successful operation.

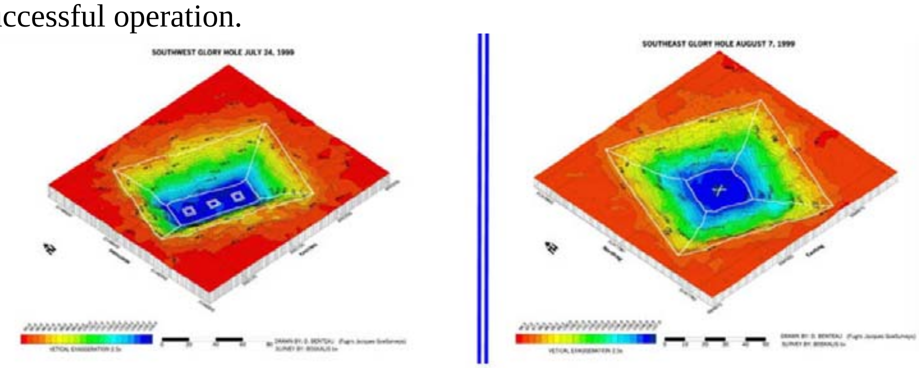

Figure 5: Drill Centre profiles as completed by the *Queen of the Netherlands*, summer 1999 [7]

Following PetroCanada's success, Husky Energy elected to create three EDCs within their White Rose field, however the increased water depth initially made using TSHDs an unviable option. In light of this, the fallpipe vessel *Seahorse* was chosen to be refit with a heave compensated grab system. Progress was delayed because several repairs to the *Seahorse*'s equipment were required due to fatigue of the grabber and boulder damage. Because of the requirement to complete all three drill centres in one season a TSHD, *Vasco da Gama*, was mobilized to assist the *Seahorse*.

The TSHD experienced significant technical issues and encountered heavy boulder concentration, as shown in Figure 6, but the combined effort of the two vessels was able to successfully complete all three drill centres within the season.

Figure 6: Boulders being cleared from *Vasco da Gama*'s draghead [7]

4 CONCLUSION

Iceberg scour presents a significant risk to hydrocarbon development on Newfoundland's Grand Banks and the additional safety requirements have significantly slowed the development of the region. However, by lowering the critical seabed equipment below the seafloor a necessary level of safety can be achieved to operate in these ice environments. EDCs have been proven to be the most effective means of protecting equipment on the Grand Banks and has been used several times by all of the major operators in the region.

Despite the formidable soil conditions that must be overcome to create an EDC, they still provide the best means of protection for offshore structures and for the development of hydrocarbons on the Grand Banks

REFERENCES

[1] Canada – Newfoundland and Labrador Offshore Petroleum Board, “Annual Report 2011-12”, C-NLOPB, St. John’s, NL., 2012.

[2] Carrick, G.J, I Delong, A.A Ewinda, and R.J Knight, "East Coast of Canada: An Industry Perspective on the Opportunities and Challenges", OTC 17575, *Offshore Technology Conference*, Houston, 2005.

[3] K. R. Croasdale & Associates Ltd., “Study of Iceberg Scour and Risk in the Grand Banks Region”, National Research Council of Canada, Ottawa, 2000.

[4] Environment Canada, “Iceberg Fact Sheet”, December 14, 2004. http://www.ec.gc.ca/glaces-ice/default.asp?lang=En&n=40E178A1-1 (accessed March 9, 2013)

[5] CSA, “CAN/CSA-S471-04: General Requirements, Design Criteria, the Environment, and Loads”, Canadian Standards Association, 2008.

[6] Croasdale, Ken, et al, “Iceberg Risk to Seabed Installations on the Grand Banks”, *16th International Conference on Port and Ocean Engineering under Arctic Conditions.* Ottawa: POAC, 2001, 1019-1028.

[7] Hewitt, Kevin, “Subsea Glory Holes: A brief Overview of Construction Methods used on the Grand Banks”, Calgary, 2007.